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Vol. 237 **JUNE, 1944** **No. 6**

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Published by
THE FRANKLIN INSTITUTE OF THE STATE OF PENNSYLVANIA
Prince and Lemon Streets, Lancaster, Penna., and
Benjamin Franklin Parkway at Twentieth St., Philadelphia, Penna.

SIX DOLLARS PER YEAR (Foreign Postage Additional) **SINGLE NUMBERS, SIXTY CENTS**

Indexes to the semi-annual volumes of the JOURNAL are published with the June and December numbers. The contents are also indexed in *The Industrial Arts Index.*

Journal
of
The Franklin Institute
Devoted to Science and the Mechanic Arts

Vol. 237 JUNE, 1944 No. 6

THE RAPIDLY EXPANDING FIELD OF USEFULNESS OF X-RAYS.*

BY

WILLIAM DAVID COOLIDGE,

Vice President and Director of Research, General Electric Company, Schenectady, New York.

A labored expression of pride and gratitude should be superfluous from a fortunate recipient of this award from The Franklin Institute, the oldest institution in the United States devoted to the promotion of applied science, founded in commemoration of the first great American scientist. The Institute is known and justly honored throughout the world, and a man would be less than human if he were not filled with pride by recognition from such a body and with gratitude for the honor conferred.

But I have additional cause for gratitude in the gracious absolution given me by Dr. Allen from presenting at this time the formal address customary on such occasions. While this award is made in my name, it is no false humility which makes me realize that I receive it, not wholly as an individual, but in large part as representative of the Research Laboratory, the personnel and facilities of which aided, and indeed made possible, the developments on which this award is based. I could not, therefore, make fitting response to this honorable award without an *adequate* reference to the work of the laboratory *as a whole*, but adequate reference to its current activities is prohibited by war-time requirements of secrecy, while records of the past lose present interest in the momentous struggle, not yet won, for freedom and the security of all the institutions we most dearly cherish.

Therefore, with your gracious permission, I now limit myself to this brief expression of pride and gratitude, in my own behalf and in that of my colleagues, for the great honor you have conferred upon me.

In what follows I shall deal briefly with a single field in which our laboratory is actively engaged and concerning which we are reasonably

* Read at the Medal Day Meeting, Wednesday, April 19, 1944.

(Note—The Franklin Institute is not responsible for the statements and opinions advanced by contributors in the JOURNAL.)

free to talk. I say "reasonably" because even here certain phases of the work are under secrecy orders.

I refer to the x-rays and their rapidly expanding field of usefulness. This expansion is due to many causes and to the constructive efforts of many men. It is due, on the one hand, to improvements in x-ray generating equipment and, on the other, to the step-by-step process of learning what this form of radiation can help us to accomplish.

To speak of the x-ray generating equipment and, first of all, the tube: the present type, the hot-cathode high-vacuum tube, in its original commercial form was limited to voltages not in excess of about a hundred and forty thousand, while later models were developed for voltages up to four hundred thousand. It was difficult to go much beyond this until we adopted the expedient of grading the potential along the tube by means of a multiplicity of tubular accelerating electrodes. In this form the tube apparently can be designed for voltages as high as can be produced. Many tubes of this multisection type are operating at a million volts and similar sealed-off tubes for two million volts have already been developed. These last produce x-rays like the gamma rays from radium.

This increase in the voltage at which the tube can be operated extends the available x-ray spectrum, for the x-ray wave-length is simply inversely proportional to the voltage, and the penetrating power of the rays increases rapidly with decreasing wave-length.

By a new method we are now able further to extend the available range of x-rays up to those corresponding to a *hundred* million volts.

In the other direction, by the use of a beryllium window in the tube, we are able to render available x-rays of useful intensity at voltages as *low* as a thousand.

In these ways the available x-ray spectrum has been extended until it now covers more than sixteen octaves.

Our eyes respond *directly* to a light spectrum embracing only one octave. By *indirection* they may be made to respond to any portion of the entire x-ray spectrum; hence we may say that, through the x-rays, the range of our vision has been extended by sixteen octaves.

Various forms of high voltage source have been used for operating the x-ray tube, including the induction coil, various forms of static machine, the high frequency coil, the transformer with and without rectifying device and, last of all, Mr. Westendorp's low frequency resonance transformer. I have omitted reference to one other source, namely, that source tapped by Dr. Franklin with his kite. Brasch and Lange working on Mt. Generoso in Switzerland attempted to make use of this. They found it potent but inconvenient. The ordinary transformer is now generally employed up to 400,000 volts, while for the range from a couple of hundred thousand to a couple of million volts the low frequency resonance transformer is especially well suited.

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For the generation of very high voltages, the use of a suitable compressed gas instead of oil as the insulating medium has resulted in a substantial reduction in size and weight of equipment.

Improvements in design resulting in the elimination of danger to the operator from both electric shock and exposure to the rays have also had much to do with their increased use. Reduction of the latter hazard—exposure to the rays—has been greatly facilitated through the development by the physicist of satisfactory devices for *measuring* x-ray intensity and through the determination by the medical profession of the x-ray dosage to which a human being can safely be exposed. This last is very important because no matter how thick the lead or other protective material used, there is always some radiation getting through.

Apparatus developments resulting in easy *portability* have made it possible, where necessary, to bring the x-rays to the patient. For war use, self-contained portable equipment, complete with its own power plant, makes possible x-ray work close to the front.

To speak now of some of the effects of the war needs:

In medical diagnostic work, a radiograph of the chest has called for a large film, usually 14 by 17 inches. The x-ray examination of the chests of all of our recruits by this method would have called for a tremendous amount of photographic film. This situation has been greatly eased by substituting for the radiograph a photograph, made with a small camera, of the x-ray shadow on the fluoroscopic screen, thus reducing to a tenth, or even less, the amount of film required. This procedure is resulting in a much wider use of x-ray diagnosis than would otherwise be practicable and will carry over into peacetime, especially for the frequent chest examination of school children.

In industry, the war has greatly increased the fluoroscopic use of the x-rays. Without such non-destructive inspection, small aluminum and zinc die-castings which looked all right on the surface would be machined and might then show defects, necessitating rejection with the loss of whatever man-hours of labor had gone into them. Such parts are now put on an endless belt and, as they pass through the x-ray beam, observed fluoroscopically. Prior to the use of x-ray examination, rejections after machining have sometimes run very high, even in excess of fifty percent. The x-ray inspection not only protects the *user* of the castings from loss of labor but also enables the *producer* of the castings to maintain a constant check upon his output with the result that he doesn't produce bad castings.

Some industrial fluoroscopic examinations have been made *entirely automatic* by substituting for the human eye a photo-cell, and by using an amplifier for the electric current produced and electro-mechanical means for either marking the defective parts or separating them from the good ones. In this way it has been possible, for example, to inspect hand grenade fuses at the rate of 4,000 per hour.

Million volt x-rays are today playing an important role in industry in the radiographic examination of various kinds of war material including welds and steel castings as thick as eight inches. Their main advantage over lower voltage rays consists in their greater penetrating power and the correspondingly shorter exposure time required. As an illustration of this, a radiograph through five inches of steel, made with a certain four hundred thousand volt outfit at a certain distance and with a certain film, requires *three and a half hours* while, with a one million volt outfit, only *two minutes* is needed.

Furthermore, the higher voltage x-rays helpfully reduce the contrast in the radiograph and so make possible the study from a single film of a specimen of widely varying thickness.

As an illustration of this I may cite the case of a magnesium alloy casting varying in thickness from a quarter of an inch up to twelve inches. A single million volt radiograph gave the information throughout this thickness range which, with two hundred thousand volt x-rays, was to be had only by making about nineteen radiographs. Another great advantage in the use of such penetrating radiation consists in the fact that with increasing voltage the secondary x-radiation produced in the object is scattered less and less in direction and hence causes less and less blurring of the shadow picture.

For industrial use, automatic machines have been developed for positioning parts to be radiographed and for making the exposures, and other automatic machines have been produced for processing the film.

The x-rays may be used as a thickness gage, without the necessity of making mechanical contact with the work, as, for example, in the rolling of sheet steel, where the sheet metal may be coming through the mill at the rate of over twenty miles per hour and at temperatures up to 2,000° F. and where, through adjustment of the mill, the thickness of the sheet must be kept within certain narrow limits. With an x-ray outfit below and an ionization chamber or other x-ray intensity measuring device above the sheet, it becomes possible through the measurement of x-ray transmission to have a constant indication of thickness and, if desired, to have the x-rays themselves control the mill so as to maintain automatically a constant thickness of the steel sheet.

Starting with the various *medical* uses, we have seen the field of application of the x-rays extend in many other directions. To mention a few of these:

They may serve as a means of chemical analysis.

They are used to measure the distances between the atoms in a crystal and so to determine crystalline structure.

In cutting quartz crystals for radio-frequency control, x-rays are used to determine the orientation of the axes, in case the natural faces, which could otherwise serve as a guide, are lacking.

Through the measurement of the spacing of atoms they make it

possible to show existing strains in structural materials—strains which if not removed might lead to structural failure.

They reveal hidden flaws in structural materials.

They may be used for the inspection of finished apparatus to check up on alignment of parts, as in metal vacuum tubes, or to show that no essential part has been omitted as in fuses.

They are used for the inspection of automobile tires.

They are used fluoroscopically for the inspection of foodstuffs such as candy, diced vegetables for canning, shelled nuts and dried fruits to guard against the inclusion of foreign bodies. They have also been used to judge the condition of fresh citrus fruits.

The very *low voltage* x-rays are used in microradiography as a means of studying the composition of very thin metallic specimens and to reveal structure in delicate botanical and zoölogical tissues.

Lastly, and to the physicist most important, the x-rays have, perhaps more than any other single agency, advanced our fundamental knowledge of the structure of matter.

The first world war greatly accelerated the *medical* use of the x-rays and this war is doing the same for the *industrial* field.

I have said but little about the medical use, concentrating mainly on the *more recent* industrial applications.

Of the sixteen octaves of the spectrum now available for study, the upper five octaves have scarcely been explored at all. Their fields of usefulness remain to be determined. It is known that as voltage is raised above a few million, penetrating power reaches a maximum, differing for different materials, and then declines, but aside from penetrating power it seems certain that the higher energies obtainable at the higher voltages will either open new fields of utility, which are as yet hardly more than fields of speculation, or will lead to an increase in our knowledge of the structure of matter, thereby in either case further expanding the field of usefulness of the x-rays.

The Gas Turbine—Present Status and Immediate Prospects.—C. RICHARD SODERBERG AND RONALD B. SMITH. (*Power Plant Engineering*, Vol. 48, No. 4.) Recent improvements in the character of the gas turbine cycle make it appear feasible now to build self-sustaining power units that are independent of a separate source of compressed air and whose operating efficiencies will approach closely those of the best Diesel engines.

Power engineers are familiar with the application of multi-stage feedwater heaters in steam plants that took place in the middle 20's and led to decreases in station heat rates from about 20,000 Btu per kwhr to 14,000 Btu per kwhr without material changes in steam pressure or temperature. Just as this development of the regenerative feed heating cycle for steam power plants led to a 25 per cent. improvement in steam plant heat rates, so the thermodynamic improvements currently being made in the gas turbine cycle indicate a possible improvement of 50 per cent. or better in thermal efficiency without exceeding a maximum working temperature of 1200° F.

By the simple expedient of reheating between expansions, intercooling between compressions, combined with exhaust heat regeneration, gas turbines can now be designed which will be competitive with other modern prime movers. The successful progress of the gas turbine is, of course, intimately tied to metallurgical developments of heat and corrosion-resisting materials.

Limiting the operating temperature to 1200° F. and using the reheat type of cycle it is possible to attain a fuel consumption (Bunker C) of about 0.45 lb. per hp-hr. with a plant weighing less than 25 lb. per hp exclusive of generators or other power absorbing equipment. The development will involve many difficult engineering problems, but none of them appears to be beyond attainment with the present metallurgical materials. Further advances in metallurgy of high temperature alloys, and further elaboration of the gas turbine cycle will make it possible to realize fuel rates of less than 0.40 lbs. per hp-hr. The maximum size of gas turbine plant which can be constructed at the present time is somewhat difficult of prediction, but 7500 hp. appears possible. The reliability of such gas turbine plants is expected to be fully satisfactory, once the early development problems have been solved. The maintenance expense should compare favorably with that of present day steam plants.

R. H. O.

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SUPER-FLUIDITY OF HELIUM II AND ATTAINMENT OF THE ABSOLUTE ZERO.*

BY

PIOTR L. KAPITZA,

Director of the Institute of Physical Problems of the Academy of Sciences, Union of Soviet Socialist Republics.

When the temperature is 2.19° above the absolute zero, liquid helium passes through the phase of metamorphosis into so-called helium II. The author, in his research into the nature of liquid helium II, shows that its viscosity is at least one billion times smaller than the viscosity of water; thus helium II may be called a flowing liquid, i.e., a liquid capable of flowing without viscosity. Basing upon this exceptional fluidity of helium II, the author offers the following explanation of that great diathermancy which has been observed by Keesom. The creation of powerful convectional currents is stipulated by special thermo-hydrodynamic forces which were uncovered by Allen and Johnson in a powder, saturated with liquid helium II, but the author discovered them also in free helium II where they always appear when a difference in temperatures exists. These currents can easily be demonstrated in a small apparatus which resembles the "Sengerov's Wheel." This apparatus, submerged into liquid helium II, begins to rotate under the influence of slight heating.

Further studies of these currents have shown existence of an exceptional case of direct transition of heat into kinetic energy of the movement of the liquid. The experiment has shown that this phenomenon is thermodynamically convertible.

While forcing helium II under pressure through a narrow slit, the temperature can be lowered several tenths of a degree. In view of the fact that this exceptional ability of helium II, theoretically, should be preserved to the lowest temperatures, an experimental method is being developed making it possible to approach absolute zero as near as it is desired. A complete explanation of the super-fluidity of helium II based on the quantum theory was given by Tisso and Landau. This explanation is close to the modern theory of super-conductivity. According to this theory, helium II is considered as a mixture of two liquids: the first with zero entropy and the other, normal helium I. These liquids can exist in the mutual counter current. The quantum theory makes it possible quantitatively to describe these phenomena and the results obtained coincide well with experimental data.

Studies of the phenomena of super-fluidity of helium II open great perspectives in the field of physics of low temperatures.

* Read at the Medal Day Meeting, Wednesday, April 19, 1944, by Dr. James Barnes. This is a synopsis of Dr. Kapitza's paper which will be published in full in a forthcoming issue.

ARMY AND NAVY NOTES.

Synthetic Rubber Gets "Baptism of Cold" Test.— (*Refrigerating Engineering*, Vol. 47, No. 5). To insure its ability to weather sub-zero temperatures found at 30,000 ft., synthetic rubber used in precision aircraft instrument production must pass a cold chamber "freeze test" at the Eclipse-Pioneer division of Bendix Aviation Corporation, Teterboro, N. J. Rubber and other raw materials used in scientific aircraft equipment must maintain physical properties at temperatures as cold as −60 deg. F.

R. H. O.

Air Conditioning Increases Quantity and Quality of Arc Welding Electrodes.—(*Refrigerating Engineering*, Vol. 47, No. 5). Air conditioning has increased the quantity and quality of stainless steel welding electrodes produced by the Paschall plant of the Arcos Corporation, Philadelphia, Pa. The company makes arc welding electrodes for electric welding.

Qualitatively, production with conditioned air also scores higher than previously. Rejects are down, because the system—specifically designed by Carrier Corporation engineers—provides uniform air velocity and constant conditions during manufacture. Speedy drying of the four coatings on the electrode keeps it from cracking on subsequent operations.

In the plant procedure, stiff stainless steel wire, delivered in coils, first goes through a straightening and cutting machine, which delivers rods 14 in. or 18 in. long. Loaded into clamps, the rods are dipped in a paste so that the metal will receive a uniform coating of flux. A number of racks holding freshly-dipped rods is then loaded on a truck and wheeled into the drying tunnel. The dipping and drying sequence is repeated four times.

The first three times, the electrodes remain in the tunnel between 1 and 2 hr. in air of 76 deg. F. and 58 per cent. humidity. The final drying takes from 8 to 10 hr. in air of 92 deg. F. and 23 per cent. humidity.

To obtain the results mentioned, Arcos installed a Carrier air conditioning system water-cooled refrigerating machine with the air conditioning equipment to obtain the low dew point air needed. The drying tunnel uses ejector nozzles for air distribution for uniform conditions of air throughout the entire drying space. The drying spaces consist of two tunnels, each 2 stage to handle the production for top quality rods.

R. H. O.

AN ELECTRON AND X-RAY DIFFRACTION STUDY OF THE GRAIN BOUNDARY SUBSTANCE IN CADMIUM.

BY

BERNARD L. MILLER.

Philadelphia, Pennsylvania.

ABSTRACT.

The grain boundary material in commercial cadmiums was isolated by dissolving laminae of cadmium in ammonium nitrate solution, the boundary substance remaining as insoluble films. Electron diffraction patterns were made of such films using 40 to 50 kilovolt electrons and X-Ray diffraction patterns were obtained of powders of these films employing copper K_α radiation. Guided by a knowledge of the elements present as indicated by a spectrographic analysis, the diffraction patterns were identified as belonging to the compounds cadmium carbonate and basic lead carbonate. It is possible that these carbonates did not exist in the metal, but were converted from oxides in the metal during dissolution of the laminae.

INTRODUCTION.

It is known that, when there are insoluble substances present in a metal, they frequently form films or envelopes around the crystal grains of the metal. The chemical composition of the compounds found in these boundary films often has an important bearing on the characteristics of the metal. In this paper, we are interested in the identification of such compounds in the case of commercially pure cadmiums. Electron and X-Ray diffraction and spectroscopic methods were used in making the analysis.

PREPARATION OF ELECTRON DIFFRACTION SPECIMENS.

The initial experiments were performed on some stock cadmium which was in the form of thin sheets covered with a layer of corrosion. The corroded layer was filed off; the sheets were polished with a rough, and subsequently, a fine emery paper. These cleaned sheets, approximately 0.3 mm. thick, were cut into laminae 6 mm. square. The laminae were degreased by immersion in carbon tetrachloride. Immediately on drying, each laminae was placed on a shallow crystal glass sitting in a petrie dish containing fifty grams of 20 per cent. ammonium nitrate solution. The source of ammonium nitrate was Merck Reagent 99.98 per cent. pure.

The polished cadmium lamina soon turned dark blue, and after remaining for about one hour in the ammonium nitrate solution at room

TABLE OF RESULTS.

Diffraction Data for Cadmium Grain Boundary Material.

List of Interplanar Spacings d/n in Angstroms.

Electron diffraction.												X-Ray diffraction.						Data from literature.			
Cadmium No. 1.								Cadmium No. 2.				Cadmium No. 1.		Cadmium No. 2.		Cadmium No. 3.		$CdCO_3$		Basic $PbCO_3$	
(1) Specimen 1		(2) Specimen 2		(3) Specimen 3		(4) Specimen 4		(5) Specimen 5		(6) Specimen 6		(7)		(8)		(9)		(10)		(11)	
d/n	I	d/n	I	d/n	I	d/n	I	d/n	I	d/n	I	d/n	I	d/n	I	d/n	I	d/n	I	d/n	I
						4.47	w					*4.47	w			*4.40	f			4.45	.33
4.30	m	4.22	ff			4.21	m			4.34	ff	*4.23	w			*4.29	f			4.24	.33
3.78	w	3.76	s	3.77	m					3.76	s	3.77	ss	3.78	ss	3.77	s	3.77	.80		
						3.62	m					*3.59	m			*3.61	s			3.61	.83
3.38	m									3.37	ff										
		3.19	f			3.26	m	3.20	m			*3.28	m			*3.28	s			3.28	1.00
2.94	s	2.95	s	2.99	s			2.94	m	2.94	s	2.94	ss	2.96	ss	2.96	s	2.94	1.00		
		2.73	m									2.71	ff	2.71	f						
2.63	ss					2.62	s	2.63	s			*2.61	m			*2.63	s			2.62	1.00
2.47	f	2.47	s	2.45	w					2.46	m	2.47	m	2.48	s	2.48	m	2.46	.50		
2.24	s	2.26	m	2.26	f	2.23	m	2.26	w	2.26	m	*2.23	w	2.28	w	*2.22	w	2.23	.03	2.23	.25
						2.12	w					*2.12	f			*2.12	w			2.11	.25
2.07	ff	2.06	s	2.09	f	2.04	w	2.07	f	2.07	m	2.06	m	2.08	s	2.06	w	2.06	.45	2.03	.17
												1.90	w	1.90	m	1.88	w	1.88	.33	1.86	.25
1.84	ff	1.83	s	1.83	s	1.85	w	1.83	w	1.83	s	1.83	s	1.84	ss	1.83	w	1.83	.80		
1.77	f	1.75	ff																		
1.69	f					1.70	w	1.71	w			1.69	w			1.70	w			1.69	.17
		1.58	f							1.59	m	1.58	w	1.59	s	1.59	m	1.58	.40		
										1.54	f	1.53	f			1.54	f				
						1.51	ff	1.50	w			1.50	w	1.51	m			1.50	.17		
												1.48	f	1.48	w			1.47	.05		
		1.43	ff							1.44	w	1.42	w	1.44	m	1.43	ff	1.42	.15		
		1.37	ff									1.36	ff	1.36	w	1.36	ff	1.36	.05		
								1.32	f			1.30	ff	1.30	w	1.32	ff	1.30	.05		
								1.26	ff	1.27	w	1.27	w	1.28	m	1.27	ff	1.26	.17		
														1.24	w			1.23	.05		
												1.20	f	1.20	f	1.21	f				
														1.18	f	1.18	f	1.19	.08		
								1.14	ff									1.14	.08		
										1.12	w							1.12	.08		
										1.02	f							1.02	.08		
								.98	ff	.98	ff							.98	.07		
										.93	ff							.94	.07		

Intensity of reflection indicated by: ss—very strong, s—strong, m—medium, w—weak, f—faint, ff—very faint

Intensities on basis of 0.00 to 1.00

* indicates that line is characteristically spotted.

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temperature, a thin, almost colorless film appeared around its edges. Later, the dark blue region became smaller and smaller as the film around its edge grew. Sometimes it required only a few hours at room temperature for the dark blue region to shrink to a speck, surrounded by and attached to the delicate film. Gradually, the speck would fade out and a complete fragile film, outlining the original shape of the cadmium lamina, would remain on the crystal glass. The film was almost always light gray, although in a few cases it was of a pinkish tinge. To insure total dissolution of the cadmium, the specimen was kept overnight in the solution. The film was washed, mounted over the 0.1 mm. hole of a specimen holder and dried in a dessicator.

Since the previous history of the stock cadmium was unknown, the investigation was continued with cadmium of a commercially pure grade. Cadmium sticks, approximately 99.5 per cent. pure, were purchased from Merck and Company. (The stock metal will be referred to as cadmium no. 1, and the Merck sticks as cadmium no. 2). Sections of these sticks were cut off on a lathe, filed, polished, and dissolved in ammonium nitrate solution in the usual manner. Because of the fragile nature of the films obtained from cadmium no. 2, they were usually mounted on specimen holders first coated with a thin Rezoglaz supporting film.

Electron diffraction pictures were made of the successfully mounted films, using an accelerating potential of approximately 50 kilovolts.

RESULTS OF ELECTRON DIFFRACTION ANALYSIS.

The interplanar spacings d/n in Angstroms were calculated from the formula,

$$d/n = C/D,$$

where C depends on the voltage of the electrons and the distance from the specimen to photographic plate, and D is the measured ring diameter. (The effective specimen-to-plate distance was determined from a series of diffraction patterns of thinned gold leaf taken at different accelerating voltages). Each d/n value should be correct to within plus or minus 2 per cent. of its value.

A tabulation of the interplanar spacings d/n and the intensities of their reflections showed that the results were not entirely uniform. A few lines appeared prominently on certain patterns and not at all on others. In the table of results are given the values of d/n for several pictures. The first four columns pertain to four different cadmium no. 1 specimens (the data of column 4 was obtained from Figure 1). Columns 5 and 6 are for cadmium no. 2 (the data of column 6 was obtained from Figure 2). There is considerable agreement in the different patterns but it is to be noted that strong lines such as 3.77, 2.94, 2.63, and 2.46 Angstroms appear in some columns and not in others.

FIG. 1. Electron diffraction pattern of cadmium no. 1 grain boundaries (specimen 4 of the table).

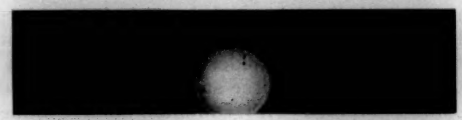

FIG. 2. Electron diffraction pattern of cadmium no. 2 grain boundaries (specimen 6 of the table).

X-RAY DIFFRACTION ANALYSIS.

An X-Ray diffraction study of cadmium grain boundaries was made in the hope of clearing up the discrepancies occurring in the electron diffraction data. Accordingly, several dozen cadmium laminae were placed in a 20 per cent, ammonium nitrate solution. After dissolution, the films were picked up in a medicine dropper and transferred to a single crystal glass. There the specimen material was washed by a slow stream of distilled water for several hours; after this it was dried by standing in a dessicator.

Diffraction pictures were taken of this material using Cu K_α radiation from a cold cathode type X-Ray tube. Patterns were obtained of grain boundary specimens of cadmium no. 1, cadmium no. 2, and of a second sample of Merck commercially pure cadmium which was obtained for the spectrographic analysis discussed below. This cadmium will be referred to as cadmium no. 3. Finally, a single X-Ray picture was made of the grain boundary films from a cadmium stick secured from the New Jersey Zinc Company.

RESULTS OF THE X-RAY DIFFRACTION ANALYSIS.

The diffraction patterns of the cadmium no. 1 grain boundaries contained two distinguishable sets of lines. One set consisted of clearly defined uniform lines, the other consisted of spotted and less sharply defined lines. This suggested that here was superposed the diffraction patterns of two different materials. (See figures 3 and 4.) The diffraction patterns of the grain boundaries of cadmium no. 2 bore out this hypothesis, since they contained the set of sharply defined lines, but hardly a trace of the spotted lines. (See Figure 5.)

Cadmium no. 3 gave the dual pattern, carrying both sets of lines. In two of the three pictures made of this cadmium, the set of spotted

lines was the more prominent of the two sets. (See Figure 6.) In the case of the single specimen obtained from the New Jersey Zinc Company, the spotted set was much the stronger. (See Figure 7.)

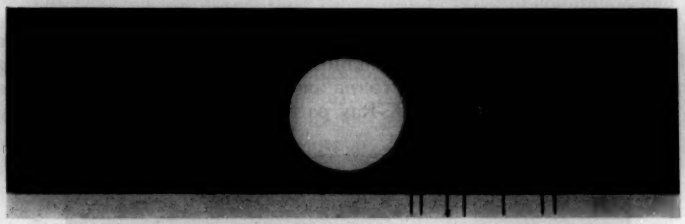

FIG. 3. X-ray diffraction pattern of cadmium no. 1 grain boundaries.

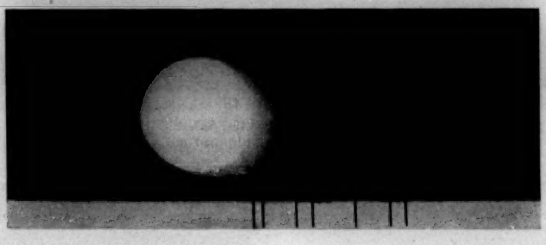

FIG. 4. X-ray diffraction pattern of cadmium no. 1 grain boundaries.

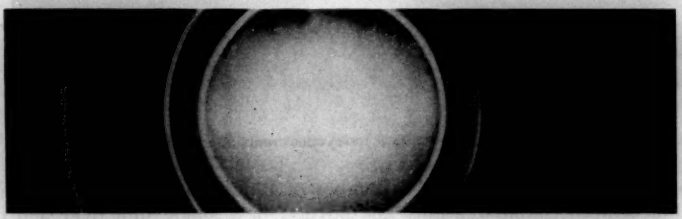

FIG. 5. X-ray diffraction pattern of cadmium no. 2 grain boundaries.

It was therefore concluded that the grain boundary films of the cadmium no. 1 and of the cadmium no. 3 metal consisted chiefly of two substances, and that the no. 2 cadmium consisted mainly of only one of these two unknown substances.

The interplanar spacings d/n for the X-Ray patterns are listed in columns 7, 8, and 9 of the table. The d/n values belonging to the set

of spotted lines are marked with an asterisk. Comparing the X-Ray values with the electron diffraction values of columns 1 to 6 shows that with the exception of only one or two faint lines, all of the electron diffraction values fall in either one or the other of the two sets of X-Ray values, and with good agreement in relative intensities.

The probable presence of two substances suggested why, on the electron diffraction pictures of cadmium no. 1 grain boundaries, strong lines had appeared on some patterns and not on others, whereas there were no inconsistencies in the X-Ray patterns of this cadmium. X-Ray

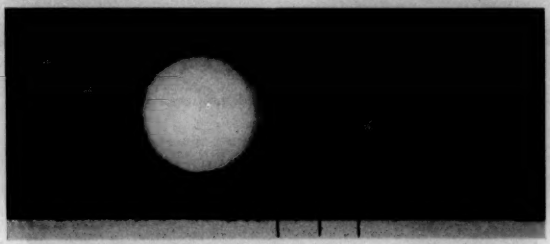

FIG. 6. X-ray diffraction pattern of cadmium no. 3 grain boundaries.

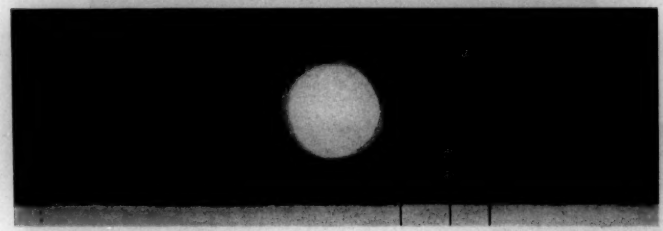

FIG. 7. X-ray diffraction pattern of New Jersey zinc company cadmium grain boundaries.

specimens were made up of a number of films; however, an electron diffraction specimen was only the portion of a single film over a 0.1 mm. hole. Now, although the two substances be well represented in film aggregates, in the small region of an electron diffraction specimen, one of the two materials might greatly predominate. Therefore, in the electron diffraction patterns, it was only a matter of chance whether one or the other, or perhaps both substances would show up. Thus, the d/n values of column 3 agree with the set of clearly defined lines, and those of column 4 are in good agreement with the values marked by asterisk. (Reference to Figure 1 reveals that on the electron dif-

fraction pattern the rings were also spotted). The data of column 1 shows that both substances were present in this specimen, since $d/n = 2.94$, and 1.84 of the set of clearly defined lines and $d/n = 4.30$, 2.62, and 1.69 of the spotted set both occur.

The electron diffraction data for cadmium no. 2 in columns 5 and 6 agree well with the X-Ray data of this cadmium, i.e., the set of sharply defined lines. However, in column 5 occur the d/n values 3.20 and 2.63 which belong to the set of spotted lines not appearing on the X-Ray pictures for this cadmium. This indivates that although the substance which caused the spotted lines did not constitute a large enough fraction of the film aggregates to show up by X-Ray diffraction, it was still present in certain individual films of this cadmium.

SPECTROGRAPHIC ANALYSIS.

To aid in identifying the diffraction patterns, a spectrum analysis of the grain boundary material was made. Such analysis afforded a knowledge of the elements present in the grain boundary substance, and this was a valuable guide in suggesting the compounds giving the diffraction patterns. Since this necessitated amassing a good deal of grain boundary material and since the supply of cadmium no. 1 and cadmium no. 2 was low, it was found necessary to order a second batch of Merck cadmium, which has been designated cadmium no. 3. Laminae of this cadmium were dissolved, and the grain boundary residues collected. This grain boundary material was analyzed spectroscopically.

The three different parent metals, i.e., the laboratory cadmium no. 1, and Merck cadmiums no. 2 and no. 3 were also analyzed spectroscopically to get an idea of the impurities present.

RESULTS OF SPECTROGRAPHIC ANALYSIS.

The grain boundary sample (obtained from cadmium no. 3) contained both lead and cadmium as the most prominent constituents, and also traces of silver, bismuth, copper, magnesium, sodium, and aluminum. The cadmium no. 3 metal itself was found to contain lead as its greatest impurity, with traces of copper and iron, and faint traces of magnesium and aluminum. The cadmium no. 1 metal also showed lead as the greatest impurity, traces of copper, aluminum, and magnesium, and faint traces of silver and iron. Cadmium no. 2 showed only traces of silver, lead, and copper, faint traces of aluminum and iron.

This analysis revealed that the essential difference between cadmium no. 2 metal and the other two cadmiums was the greater presence of lead impurity in the latter two and that the sample of cadmium no. 3 grain boundaries contained both cadmium and lead prominently.

IDENTIFICATION OF DIFFRACTION PATETRNS.

The diffraction data of many cadmium compounds were examined. Agreement was found only with the interplanar spacings for cadmium

carbonate which satisfactorily checked the set of uniform lines. Column 10 of the table gives the diffraction data of $CdCO_3$ taken from the literature.* The agreement with the set of uniform lines, typified by column 8 of a cadmium no. 2 specimen, is very good in d/n values and intensities.

The d/n values corresponding to the set of spotted lines were not in accord with those of any cadmium compound. Since spectrum analysis had shown that lead was a major constituent of the cadmium no. 3 grain boundaries, for which the X-Ray diffraction patterns had always shown the spotted set of lines, attention was directed to the lead compounds. Column 11 of the table gives the interplanar spacings of basic lead carbonate, $2PbCO_3 \cdot Bb(OH)_2$.† Excellent agreement is seen between these and the asterisk-marked values of column 7 and 9.

DISCUSSION OF RESULTS.

The electron diffraction and X-Ray diffraction methods have shown that cadmium carbonate and basic lead carbonate were the predominant constituents of the grain boundary residues. That the $CdCO_3$ was not just an end product for undissolved cadmium metal was demonstrated by an experiment in which spectroscopically pure cadmium laminae, prepared at New Jersey Zinc Company by sublimation in vacuum, were dissolved in the ammonium nitrate solution in circumstances identical with those of the other cadmium laminae. There was no trace of any residue showing the dissolution of the cadmium, itself, was complete.

The appearance of the basic instead of normal lead carbonate is to be expected since it is known that the normal form converts to the basic form in NH_4NO_3 solution.‡ It may be that this conversion was accompanied by a grain growth leading to the lack of random crystal orientation, as indicated by the spotted diffraction lines.

Although the carbonates were found in the grain boundary residues it is unlikely that they existed in the metal because the temperature reached in processing the metal would convert them to oxides.

ACKNOWLEDGMENTS.

The writer wishes to thank Dr. J. Sherman of the Test Laboratory, Navy Yard, Philadelphia, for making the spectroscopic analyses. The writer also gratefully acknowledges his indebtedness to Dr. Raymond Morgan for suggesting this research, and for many helpful suggestions throughout the work.

* *Industrial and Engineering Chemistry*, Analytical Edition, v. 10, no. 9, Sept. 15, 1939, "Chemical Analysis by X-Ray Diffraction," by Hanawalt, Rinn, and Frevel.

† *Industrial and Engineering Chemistry*, Analytical Edition, v. 10, no. 9, Sept. 15, 1939, "Chemical Analysis by X-Ray Diffraction," by Hanawalt, Rinn, and Frevel.

‡ Mellor, Inorganic and Theoretical Chemistry, VII, p. 837, 1927.

AN UNEXPLORED MUSICAL RESOURCE.

BY

EDWARD MURRAY AND HOWARD LINN EDSALL.*

On a late spring afternoon, with fog blowing along the deserted New York waterfront near Coenties Slip, a blind man halted at the sound of curious music, brief, unearthly, and oddly focussed in one spot, as in a whispering gallery, for his sensitive ear alone. For a short space of time it seemed to him that music of sublime effect was coming from the air, from the river, from the brick walls, and from the wet pavement in front of him.

By every known composer's standard it was not man-made music at all, except that it had absolute rhythmic certainty and a breath-taking beauty, like a gentle thematic statement by a 100-piece symphony orchestra. A shop door had been left open, and then it was closed, and that was all. He was, in fact, standing near the Famous Clock Shop on West Street. Yet something had come out of the door on the warm shop air, and something remained. He was conscious of a vital emotional experience, unlike anything he had known before.

Out on the river, muted by distance, came the uneven far-off whistle notes as three ships maintained speed in the channels, each sounding a warning blast at regular intervals. Occasionally the notes came together like a chord, blending and breaking again. He had been hearing them for a long time, not noticing. But then, and suddenly, there had come from the clock shop near at hand the fascinating parallel rhythms of myriad clock and watch escapements, each with a separate firm tempo, hurried or slow, and each with an individual pitch and voice, somehow clinking rather than dully ticking, beating time with metronomic precision, swelling in cross accent as several took the same beat and reinforced it before catching the beat and tempo of another series. It was like overhearing the music of the spheres, the rhythms of the universe. The effect was electric, vibrant with life.

The experience, far from being purely a surface stimulus, was so vivid that it left him with the feeling of being on the threshold of discovery, as inventors are said to be when some spontaneous manifestation of natural law evokes a question and a fascinating, partial glimpse of the answer. Did there exist, then, an unexplored musical resource

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which might further advance the art of musical composition? If so, what was the unifying principle by which phenomena, seemingly not closely related, might be gathered into a formal hypothesis, so that the artist, working creatively, could synthesize and put together new materials of sublime effect?

Certainly there was need for such a resource. The composer today faces problems differing in form but not in essence from those faced by every other artist, by the scientist, statesman, and business executive. On the one hand, he must continue to utilize those basic and timeless elements which lie at the heart of some of the great music we love. On the other, he requires, and his listeners require, far greater resources of expression. But if he uses a new resource, it should be of such kind, and used in such manner, that he can more perfectly assimilate and dominate his other material. The new resource, moreover, should help him to perceive the wellsprings of eloquence and passion that lie concealed within what appears to be a simple pattern. It should help him to express his wider consciousness of mankind, without losing that depth of emotion, the tradition of which has been bequeathed to him by the masters.

MELODIES ON ONE PULSE.

That tradition, by which any new resource must be scrutinized, is reflected, on the purely scientific side, in the observation of Henry James, who said that music is a form or method of hypnotism. We may accept the jibe, and note that hypnotism, to attain its effect, as it does in great music, needs a recognizable, fundamentally repetitious and consistent motion, a rhythmic beat, a steady pulse, moreover, in which alteration, if used at all, is used sparingly. Thus one feature that characterizes much of our great music of the Western world is the underlying consistency of all the themes in any one movement. In the Beethoven Fifth, for example, even the Scherzo-Finale is made up of a series of melodies, all erected upon the same pulse. So also is the first movement of the Eroica and the Finale of the Jupiter. The first two movements of the Sibelius Fifth, with the long *accelerando*, would appear to be an exception. But even here it is obvious that in the Scherzo, Sibelius has chosen to present the same thematic material at a higher velocity; he has not selected themes which cannot be played within the original pulse.

In the Finale of the Brahms Fourth, up to the *piu allegro*, there are more than twenty-five musical ideas, all evolved out of a fundamental and almost mechanically unchanging pulse. The end of the movement is, like the Sibelius, at a higher tempo, and it also uses the first theme, simply played at greater speed.

So it is that one of the distinguishing powers revealed by the great masters [1] is that of conceiving a long series of thematic ideas, all derived from and expressing the same pulse; and music which has been

thus conceived is, at least in this respect, more likely to exhibit qualities of strength and appeal for which we treasure great works.

But there is this seeming paradox in relation to the requirements of an almost hypnotic rhythmic pattern. The Western mind is not content to leave any musical resource in what might be called a raw state. Sooner or later it insists upon converting that raw material into melody, and eventually into melody that will be comprehensible even to the least cultivated of music lovers. Obviously, the unifying principle suggested by hearing a hundred clock and watch escapements against a series of distant whistle blasts would seem to violate the first canons of the art, except for a phenomenon so well known to students of the music of Africa and India. According to J. Tasker Howard,[2] combinations of rhythms are child's play to primitive peoples. "It is no feat at all," he says, "for an African musician to sing in one rhythm, beat his drums in another, and stamp his feet in a third. And, if you want to hear really complex rhythms, listen to the album of RCA-Victor records recorded by the musicians who play for Shan-Kar,[3] the Hindu dancer."

COINCIDENT METERS.

The unexplored resource is nothing more nor less than the writing of contrapuntal lines in different time signatures, in ratios more extended than 2 against 3, or 3 against 4. It will be referred to as *coincident metric patterns* or *coincident meters*. It may be noted that everyone enjoys the vital and stimulating experience of hearing or playing both syncopations and cross accents. Coincident meters are merely syncopations and cross accents which, from being occasional and spasmodic, have been erected into a formal and established musical structure. Bearing only a subtle relationship to each other, coincident meters must not conflict to produce chaos, but blend or coalesce to form a newly integrated rhythmic and contrapuntal architecture, incomparably richer in thought and feeling-potential than those which now no longer satisfy, as evidenced by the fact that mannerisms, striking devices, and irregularities of every sort are being pushed to the limit in much music today.

It will be perceived at once that while coincident meters resemble those of Africa and the East, there is a fundamental difference. It is not simply a matter of formalizing them, as will appear. In the first place, neither African nor Eastern music gives the impression of two different rhythmic patterns played simultaneously, but rather of one predominant meter, broken into small and rapid subdivisions. The complications are not independent; they are plainly derived.

In coincident metric patterns, on the other hand, while one may derive from and reinforce the other, it is erected into an independent melodic line, and it may be set deliberately against the first if the effect so demands. Moreover, while there are occasional examples of true coincident meters in Eastern music, they are never sustained; they last

only a few beats. McPhee [4] cites such examples which, as he points out, are familiar in American jazz. Thus there is the further difference of duration or extent. Coincident meters are sustained.

In the Shan-Kar music, there are many passages in which a slow pulse (meter) is interrupted by a faster one that is likewise derived by cross-accenting. After a very short excursion into the quickened pulse, the slower will be resumed, as if the actual feeling of the slower pulse was meant to carry through the digression. That is a kind of tentative coincident meter, and it is common also in Western music. In fact, it is doubtful whether Shan-Kar music reveals anything that, with patient disentangling of drum parts, could not be reduced wholly to Western notation. Meters include 3, 4, 5, 6, and 7, with arresting interpolations.

It is significant that both these systems of music, groping as it seems, artlessly, toward the principle of coincident meters, have achieved an expression of states of refinement, subtlety, and power which would not be thought possible with the instruments at their disposal. However, their musicians are under less constraint than ours. Having to compose but one melodic line and to accompany it solely by percussion, they can give rein to their rhythmic inventiveness unaware of the demands of harmony and counterpoint. Notwithstanding this difference, their systems show that the musical consciousness of mankind may find in coincident meters both validity and permanence. It might be accepted as a function of Western music to vivify and enhance these toneless rhythms of Africa and India by applying to them the color and poignance of harmony and counterpoint, coordinating all the resources, fusing them into forms of unimaginable power and beauty.

There, in fact, lies the basic difference. True coincident meters are set in *musical tones*,—not merely in percussion. They are sustained and independent melodic lines, as may be seen in perhaps the simplest and most comprehensible Western manifestation that may be devised, an arrangement of coincident meters for a theme so outworn that a trifling rhythmic manipulation will not seem a desecration. See Fig. 1.

This arrangement (Rubinstein's *Melody in F*) shows the principle of coincident meters on a familiar groundwork. Of the original text, the melody, the bass tones, and the harmony have been retained. The original figuration has been adopted for bass and tenor. The soprano and alto have been recast, with a new melody in 5/8 time, and with repeated notes in the alto serving to maintain the new beat of 5 against the 4 eighth notes of the lower voices. A few new dissonances appear, prepared and resolved in the conventional manner. The marks for rhythm |. . . . |. . . . |. . . . show the exact incidence of the two rhythmic patterns.

The pianist will note and count the five subdivisions, letting each first count fall on an eighth note of the tenor or bass. He will place

the notes of the new soprano and alto on the numbered subdivisions, as shown in the first eight measures.

The subdivisions which are the most troublesome to place correctly are the underscored four (4) and the underscored (3). If special emphasis is placed upon these, the pattern will be learned more easily.

It will likewise be found easier at first to ignore ties in the 5/8 melody, to repeat quarter notes as if they had been written as two eighth notes, and in the pairs of sixteenths, to play only the first, ignoring the second. In other words, to play an octave or a group of notes on every one of the underscored subdivisions, repeating the last written notes where necessary, until the pattern becomes easy, and the mind can be transferred without difficulty from one meter to the other; then the 5/8 melody can be played as written.

This arrangement should at first be played slowly and precisely, as in the 2 against 3 exercises with which every pianist is familiar. After several repetitions the player will begin to feel the pulse of 5, while automatically maintaining the original 4. He should emphasize the new pulse. Very soon the tempo may be increased to the *moderato* of the original, and then the magic of the coincident meters will begin casting its spell.

TENTATIVE USE OF PRINCIPLE.

That it is a magic of broad appeal to the widest variety of temperament is evident in the tentative use of the principle by serious composers since the time of Bach, as well as in the free polyrhythmic improvisations of swing music. Naturally, the first treatments were in a simple form, usually derived, and very short, as in the music of the East. In Schumann and Chopin, mixed rhythms are sometimes found, 4 against 3, on a small scale. These, however, are not actually two melodic lines in different time signatures, but accompaniment against melody.

Some of the foremost later composers, Brahms, Mahler, Scriabin, added passages, still derived, yet coming close to a positive coincident metric pattern, used deliberately for variety, a fact noted by Jaques-Dalcroze:[5] "The rhythm of today (1928) obtains its originality from dissociation of movements, the synchronism of different and contrasting themes. The study of two's against three's, three's against four or five's, seven's against three's or four's, is facilitated by examining the works of Stravinsky, Malipiero, and Honegger, as well as those of their immediate predecessors, Richard Strauss and Debussy. . . . Special attention should be given to analyzing the mathematical relations of unequal superimposed time-lengths which made Arabic rhythms an inexhaustible mine of original suggestion."

Jaques-Dalcroze was then speaking of the practice of eurythmics.[6] One of its principles has especial bearing on the playing and conducting of coincident meters. One relearns through Dalcroze and eurythmics
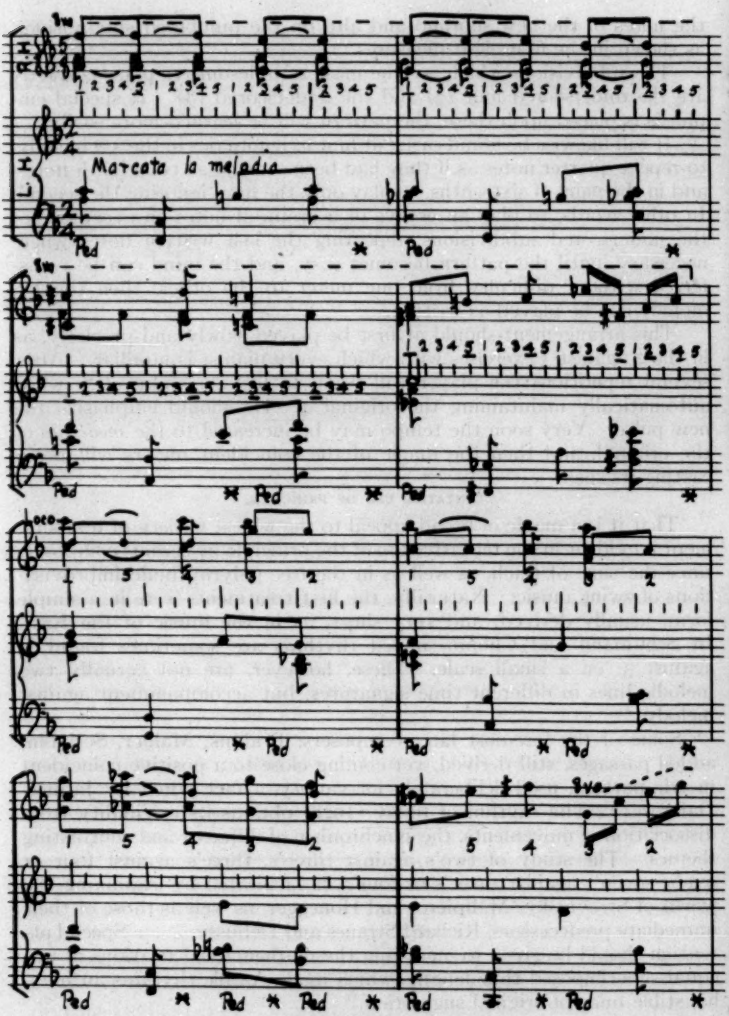
FIG. 1.
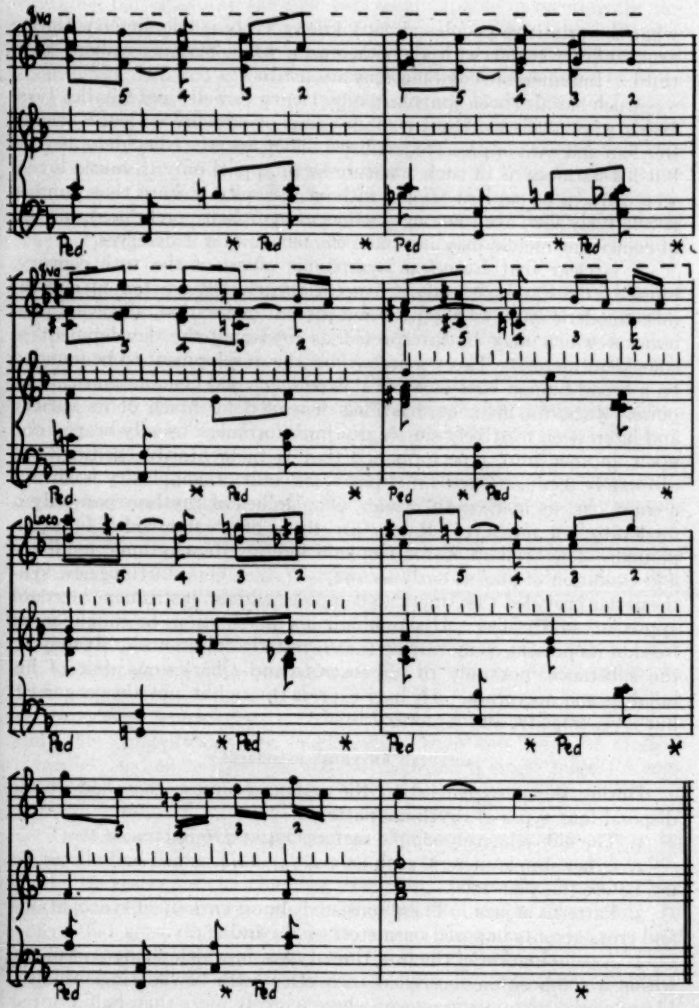
FIG. 1.—*Continued*

what the primitive peoples already know: To beat one meter with one arm, another meter with the other arm, while perhaps walking in a third. Innumerable combinations are used.

Much has also been contributed by Henry Cowell [7] and Charles Ives. Ives's work utilizes irregular subdivisions of measure with the utmost freedom and with impressive fertility. They are true coincident meters, but his harmony is of such a nature as to appeal only to music lovers who can accept modern idioms without difficulty. Since that number is relatively few, even among patrons of symphony orchestras, his use of coincident meters may not have the recognition it deserves.[8]

It is clear that European symphonic music of the 19th century, music of the Far East and Africa, the theory and practice of eurythmics, modern music of the past and present generation, all reveal phenomena which may be interpreted as presaging the development of coincident meters. These sources show the development to be founded on a broad human base of musical experience and genuine musical impulse. Jazz, for instance, has long depended for much of its variety and interest on relatively simple rhythmic formulas, usually heaped one upon another into a performance that is momentarily exciting, but ultimately confusing and fatiguing. The unit of complexity is always a short one, as in Eastern music. The arches of rhythm span only a moderato 4–4 measure. Rarely are those of greater width fully exploited. The brilliant Aaron Copland foresaw the rhythmic tendency and evolution of jazz as early as 1927. ". . . This startling new synthesis has provided the American composer with an instrument he could appreciate and utilize. It should stir his imagination; he should see it freed of its present connotations (i.e., arrested adolescence). It may be the substance, not only of his foxtrots and Charlestons, but of his lullabies and nocturnes. He may express through it, not always gaiety, but love, tragedy, and remorse." [9]

ACCEPTED RHYTHMIC RESOURCES.

During the past generation the serious composer has had at his disposal four types of rhythmic patterns:

1. The old, relatively simple meters, 2/4, 3/4, 6/8, etc.

2. Other simple meters, such as 5/4, 7/4, 11/4, which had almost no use before the year 1900.

3. Patterns of jazz. These consisted almost entirely of syncopations and cross accents imposed on meters of 2/4 and 4/4.

4. A combination of the first three types, in which changes of meter within a composition succeeded each other with bewildering rapidity. Many works contained passages where scarcely more than half a dozen consecutive measures were written in one meter.[12]

But it is an inexorable axiom of design that the more often a pattern is to be repeated the simpler it must be, and of these four types of

rhythmic patterns only the first two seem capable of meeting the demands of symphonic writing, which is, by definition, long. Devices that seem refreshing, or at least acceptable, in a short work, are intolerable if used too often in a long work. In a long series of rapid metrical changes—a series completely lacking in design—restlessness must be accepted as either desirable or unimportant; but in whichever way it is accepted, the result will be confusion. It is as if each day were to be assigned a different number of hours, decreed by a dictator at the last moment before a movable midnight. This is one complexity modern life has been spared, but not always in music. Yet it is doubtful whether long works of permanent worth can be erected on a base which is other than fundamentally regular and sustained.

On the other hand, the traditional meters have become a kind of neutral zone, useful where no special quality or emphasis is required. All possible patterns have been used so often that for the composer they seem to have lost appeal. They have lost their salt. "If the salt have lost his savor, wherewith shall it be seasoned?"

The other simple meters, 5, 7, and 11, invariably group themselves into successions of 2 and 3. In a long movement the result is again—restlessness.

There remain jazz patterns, "hot" or otherwise, with such well-established connotations of flippancy or sentimentality that they are robbed of nearly all value.

It would appear, then, that the use of coincident meters alone has expanding and unexplored possibilities for long works, giving wide latitude for variety and satisfying the fundamental requirement of a sustained, almost hypnotic rhythmic identity of pattern. Richard Rodgers [10] observes that the first rule of showmanship is change of pace. He is referring specifically to the change in tempo, meter, and style, from song to song, of a musical comedy. For the serious composer the necessity for change of pace is hardly less compelling. At the same time, his compositions are much longer than the songs of musical comedies, and since it is desirable to maintain a single pulse for considerable periods, the advantages of coincident meters are worthy of full exploration.

They have limitations, of course. It is certain that they can be given clearest expression only where a variety of tone color is available, in the orchestra, in the chamber ensemble, and on the organ. They are not as clear in two piano arrangements, still less in solo piano. In voices they seem difficult to learn because of the necessity for exquisite precision in attack, though once mastered they could be effective. They would, of course, be of fragmentary effect on any solo stringed instrument, however skillful the technic. Again, in solo piano, as seen in Fig. 1, the arrangement must include two distinct melodic lines, with harmonic tones and bass tones where necessary. The number of differ-

ent textures is severely limited in which these elements can be encompassed by ten fingers. For the most part, as in a large proportion of piano literature, the very ideas and conceptions of the music must be governed by the physical necessities of the keyboard. This gives preference to almost any instrumental ensemble for comparative ease and clarity of performance and effect.

Some of the more obvious difficulties of performance turn out to be far less redoubtable than might be supposed. In the orchestral score of Fig. 2 is shown one complete measure of a Chaconne. In this variation the coincident meters are 7 and 5, apparently formidable enough. In the meter of 7 is written the melodic line, shown in the flutes at the top, in the trumpet near the middle, and in the violins, near the bottom of the score. The meter of 7 is supported by the steady beat of a tenor drum, shown on a line just below the middle.

The bass line, as well as the obbligato line in 8th notes, is written in the broad meter of 5, shown in the 5 subsidiary measures divided by bar lines. This meter is also decorated by a syncopated figure, played by the tympani and by the wood block, shown in lines just above and just below the tenor drum. Parenthetically, it may be remarked that the melodic line used in the bass of the entire variation is so broad that one measure can convey but little sense of its melodic movement or phrasing.

The words *Ritmo di 5 battute* indicate to the oboists, on whose line they appear, that the measures are in groups of 5, and that each measure comprises one beat. The oboists have been playing in the 7 meter, and these words give them notice that they are commencing on the 5.

The time-signature 7/♩♩♩♩♩ shown on the Flute, III Trumpet, I Trombone, and II Violin, is an indication to the players that the measure comprises 7 groups, each of 5 eighth notes. In this meter, a half note is used to include 5 eighths, instead of the usual 4, largely for visual convenience to the conductor and the player. Conventionally they might have appeared thus or . These eighth notes are heard in other instruments (oboes, English horn, and clarinets).

This page of the score could be reduced to any instrumental combination that provides 5 independent voices:

Bass—playing from the Contrabass part.
Second tenor—from the I, II, III Horn part, and transposing a perfect fifth down.
First tenor—III Trumpet, transposing one whole tone and one octave down, or reading the I Trombone part.
Alto—I and II Oboe.
Soprano—I Violin.

In any case, it would be preferable to have the Bass, the Second Tenor, and the Alto (the voices in 7/8) in one color; and the First Tenor, and Soprano (the voices in 7/♩♩♩♩) in another color. The three upper voices can be doubled in the octave.

The passage itself may be considered emotionally as a variation, leading to the climax of the work, having as its basis an image of a triumphal procession in ancient Rome, with the glittering trophies, the captives, the victorious army, the barbaric music, all expressing the splendor and cruelty shown by proud, ruthless conquerors of another day.

The difficulty involved in coincident meters is not that they are complicated, but that for their performance they require a degree of sensibility and power of coördination in excess of the general average of training. Only conductors and others with pronounced rhythmic sense will grasp them without effort. But even a competent conductor, for example, will require an hour of private rehearsal before he can beat with confidence the 7 against 5, as shown in the diagram, Fig. 3, with the instructive detail.

Scores of this sort are likely to have almost a mechanical appearance, like the clock face in a radio studio. But when musicians are trained in patterns of this type, as can be expected ultimately from the trends in modern music, then many of the mechanical lines may be omitted, and no one will imagine there is anything unusually difficult in a rhythm of 5/8 against 2/4. Our symbols for indicating pitch are just as mechanical, yet we no longer object to them. Nobody who enjoys the comfort and hospitality of a home worries about the mechanical rigidity of the architect's drawings. Symbols of communication from one musician to another are in themselves merely the apparatus of technical description, and they have nothing to do with the quality or the vitality of the music they express.

It may be felt that music written in coincident rhythms must of necessity be too intellectual, despite the spacious freedom promised for them. But intellectuality is also one of the components of good music. Whether any composition has too much of that component cannot be determined until it has been heard a reasonable number of times by audiences who have a fair acquaintance with the accepted literature of good music. That is because musical appreciation is three parts memory. Nor should coincident meters be considered valueless because some one composition involving them turned out to be much too austere. Even if that were proved by the audience-response, the value of coincident meters as an unfathomed musical resource would not be affected, since deficient vitality might be attributed to the composer or his talent.

Certainly, in the year 1944, the world is well stocked with composers who are incapable of vitalizing the material they do use. That need not condemn either the material or the age; it may reflect merely a lack

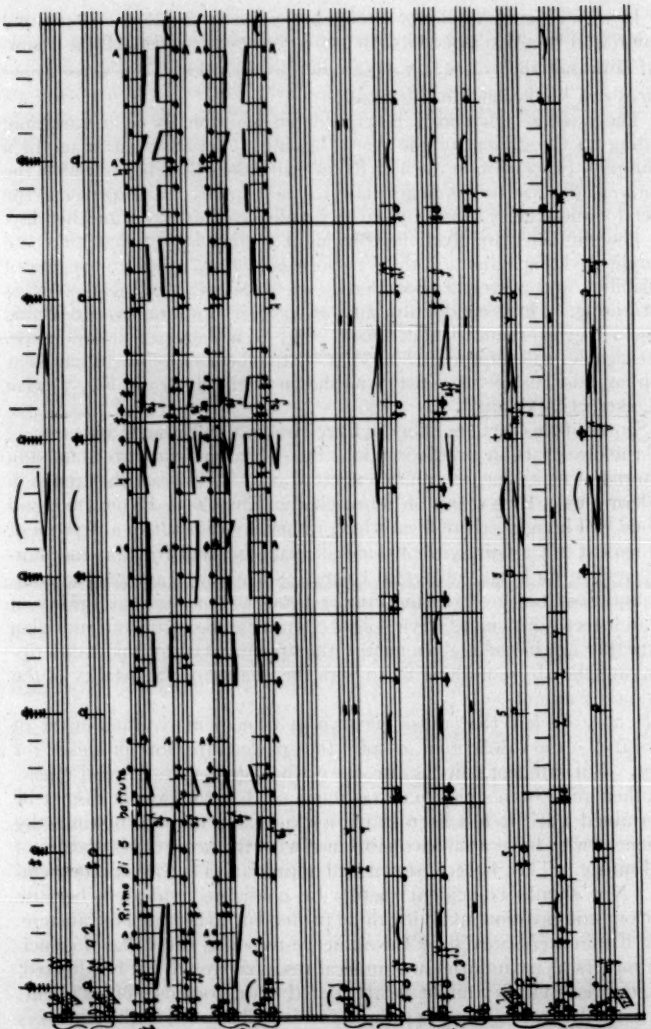

FIG. 2.

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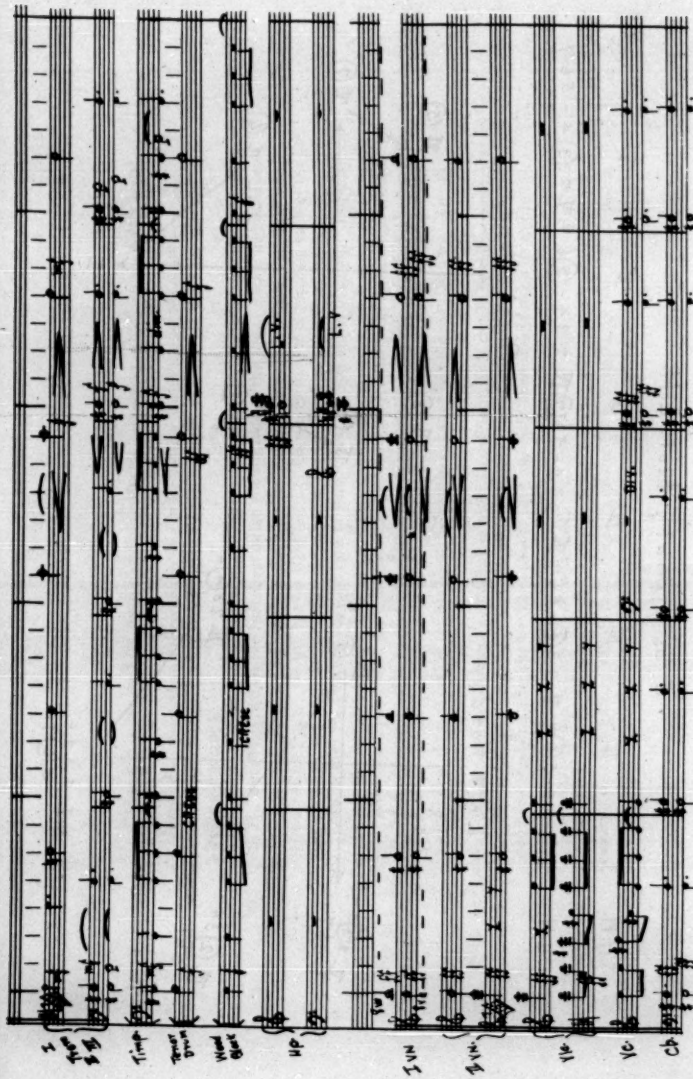
FIG. 2.—*Continued*

5 WITH 7

5 as primary beat. L.H.

R.H. I II III IV V VI VII

L.H. I 2 3 4 - 5 (6) 7 II 2 3 (4) - 5 6 7 III (2) 3 4 - 5 6 (7) IV 2 3 4 - (5) 6 7 V 2 (3) 4 - 5 6 7.

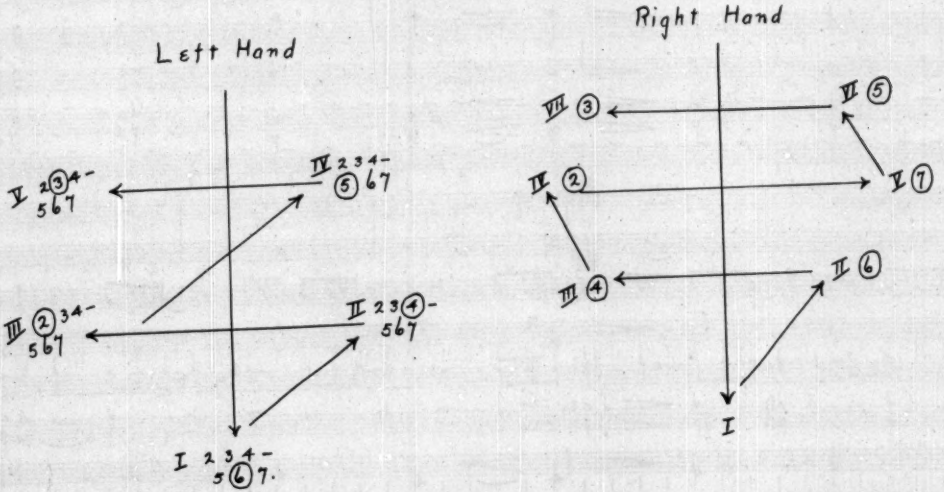

FIG. 3.

INSTRUCTIONS FOR CONDUCTOR'S DIAGRAM

Figure 3 is designed for the use of the conductor. It shows, what any conductor could readily work out for himself, the coincidence of the two meters of 5 and 7. For acquiring command of this pattern the conductor begins by beating 5 with his left hand, allowing seven counts to each beat. It will be advisable for him mentally to subdivide the 7 into a group of 4 plus a group of 3.

This beating and counting is summarized in the line of figures commencing with the letters L. H., and illustrated in the beat-diagram on the left side of the page. While he continues this beat and count, he will begin to fix his attention on the series of digits that have been circled: 6 4 2 7 5 3. He will use his right hand to tap at the instant of reaching each of the circled digits, the while he continues to beat with the left hand and to count.

These taps are shown in the two lines of numerals at the top of the diagram. The taps will be a rudimentary form of the beating of the right hand.

When the tapping with the right hand can be done with precision and certainty, it should gradually be converted to beating, following the diagram on the right side. In the right hand diagram the second beat is marked 11 6. This shows that the second beat of the right hand, coming after the first beat of the left hand, falls at the instant when the count of 6 has mentally been reached.

Meanwhile, the left hand is proceeding to its second beat, as it should be doing without pause (see left hand diagram), and the mind is continuing to count. On the instant when the mind reaches 4 after the left hand second beat, the right hand should reach its third beat. Other beats follow as the diagram indicates.

Concerning this pattern two observations will be noted. First, that of the series of circled digits, the 6 and the 4 are the most difficult to place correctly, and require special attention; second, that this pattern will be much easier to master for any conductor who has studied in regular order the entire series, beginning with the coincident meters of 2 with 3, and 3 with 4.

of talent or insight. In any age, and in any art, one of the obligations of the artist is to choose material that he can vitalize. One of the advantages of coincident meters as a system worthy of fullest development is that the problems it poses in the use of material are definite; as such they can be attacked often enough so that the composer has a chance of ultimate success in vitalizing the material.

That means using the resources of tone (i.e., rhythm, melody, harmony, counterpoint, dynamics) in such a way that the end-product, the composition, carries a burden of emotion with both significance and value to listeners who are familiar with the literature, conventions, and even the decorum of the musical art. If after a reasonable number of hearings, an experienced music lover finds that for him a certain composition does not carry a burden of emotion, significance, or value, then for him that composition is a failure, and he should waste no more time over it. If after the lapse of some years he wants to give it another chance, that may be evidence of growth. No valid conclusions respecting coincident meters can be reached until conditions of this kind have been met.

For a long time dissonance and startling effects were regarded as the likeliest means for solving problems of modern expression. Now that the belief in them is being moderated, it may be wise to study the possibilities of coincident meters. As inescapably as others is the composer caught in the pinch of alternatives, first in his relation to musical resources, and especially in his relation to rhythm. If too much of the old is dropped, the solution can grow no roots; if too much of the new has been embraced, it cannot be brought alive; if the work has been done too quickly, the material has not been digested; if too slowly, then the stream of events will have shifted its channel, and the bridge of his solution will span the empty air. Coincident rhythms are not new. They are only unexplored. How much so is shown by the fact that they appear, even tentatively, in only a small fraction of modern music, and the whole of modern music itself occupies only 15 per cent. of the symphonic programs of the country, supported by some 15,000 per 6 or 7 million population, as in New York.[11] Greater scope is possible. Perhaps this paper, by gathering a number of phenomena, seemingly not closely related, into a formal hypothesis, will in some small degree further that end by focussing attention on one of the greatest of all our unexplored musical resources.

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BIBLIOGRAPHY.

1. "A History of Musical Thought," by Donald N. Ferguson. Crofts, 1935.
2. "This Modern Music," by J. Tasker Howard. Crowell, 1942, p. 180.
3. "Hindu Music," Number M382, Victor Recording.
4. "Eight to the Bar," by Colin McPhee, *Modern Music*, May, 1943, pp. 235–242.
5. "The Rhythms of Tomorrow," E. Jaques-Dalcroze, *New Music Review*, Jul. 1928.
6. "The Importance of Being Rhythmic," by Pennington. Putnam, 1925, p. 23.

7. "New Musical Resources," by Henry Cowell. Knopf, 1936. 1930.
8. "Three Places in New England," by Charles Ives. *First Movement from a Symphony:* "Washington's Birthday," New Orchestra Series No. 20, Oct. 1936.
9. "Jazz: Structure and Influence," by Aaron Copland, *Modern Music*, Jan. 1927.
10. "How to Write Music in No Easy Lessons," by Richard Rodgers, *Theatre Arts Monthly*, Vol. No. 23, Oct. 1939.
11. "Our Orchestras vs. the Modern Composer," by Ronald F. Eyer, *Musical America*, June 1943.
12. Rapid sequences of meters may be found in: *Suite of Dances*, by Bartok, 1924; *La Poème de la Forêt*, by Roussel, 1909; *Les Noces*, by Stravinsky, 1923; *Le Sacre du Printemps*, by Stravinsky, 1913.

ARMY AND NAVY NOTES.

A Hasty Method of Waterproofing Runways.—WILMOT R. MCCUTCHEN, Major, Corps of Engineers. (*The Military Engineer*, Vol. XXXVI, No. 223.) Army engineers charged with the job of constructing military airdromes in various theaters of operations are constantly faced with the problem of protecting runways, taxiways, hard standings, and access roads from the effects of protracted periods of rainy weather. Permanent runways, made of concrete or asphalt, are stable and usable in wet weather, but they consume prodigious amounts of material, equipment, and time in their construction. What is needed is a means of waterproofing soils, and an answer lies in the admixture to the soil of a small quantity of a substance which will make the soil water-repellent. In addition, this material should be light in weight, non-corrosive, stable in composition, and, above all, simple and easy to apply.

Experiments were conducted at an air base recently employing a new type of resin-salt compound, and the conclusions seem to indicate that a workable solution may have been found. A compound has been tried which is easy to apply, being packed in convenient 50 pound bags and requiring only from 0.5 to 1.0 pounds per square yard mixed in to a depth of 4 to 6 inches to make the surface water-resistant. It is mixed into the soil in its original form and does not require a slurry.

Tests have proven that soil mixed with this substance apparently becomes quite water-resistant. A large, flat basin was made of this soil mixture which was designed to catch and hold rainwater. The puddle thus formed has never dried up. If the treated soil beneath the puddle is scratched with a stick, perfectly dry dust will come up through the water. The ground beneath is still hard and dry, even though this same puddle has now been standing for over two months. A 2½-ton Army truck was run back and forth through the puddle without skidding or making ruts in the ground.

Time has not permitted tests to be made on soils other than sand, sand-silt, or sand-clay mixtures. While these tests have been meager, it is believed that their results have met with enough success to warrant the further consideration of this method of waterproofing soils in hasty runway construction.

R. H. O.

NOTES FROM THE NATIONAL BUREAU OF STANDARDS.*

OUTPUT OF OVER-AGE DRY BATTERIES.

The lack of an adequate supply of dry batteries for the civilian market has fostered the sale of over-age batteries which are no longer desired for military purposes. This has given rise to considerable interest in information which the Bureau has accumulated on the deterioration of batteries in storage. The qualification tests regularly made at the Bureau in connection with Government purchases of dry cells and batteries have given a large amount of information regarding the performance of cells after storage periods of 3 and of 6 months. Reports summarizing the results of such tests made during recent years have been supplied to a number of Government agencies, including the Office of Price Administration. The amount of depreciation naturally varies considerably among the different types and sizes of cells and the conditions under which they are stored, but cells of good quality of most types after 6-months storage will give at least 80 to 90 per cent of the output of new cells. The smallest size which the public buys, however, may range from 60 to 70 per cent. Sample lots of dry cells now available on the market are being tested for the Office of Price Administration.

THERMAL PROPERTIES OF MOIST FABRICS.

Practical experience has demonstrated that moist fabrics in contact with the body produce an unpleasant sensation commonly referred to as a "chilling effect" or a "clammy feel." The degree of the sensation varies with different fibers and fabrics; thus, on the basis of general experience, the merits of wool fabrics over similar cotton fabrics have long been recognized. This is one of the reasons, for example, for the preference usually given to woolen underwear and other garments for use in cold climates under conditions where physical labor causes considerable perspiration. It also accounts for the approval commonly expressed for woolen bathing suits. In order to obtain factual data to explain these preferences, and to evaluate the various factors which contribute to the chilliness or clamminess of wet fabrics, an investigation of this phenomenon was undertaken by Charles W. Hock, Arnold M. Sookne, and Milton Harris, research associates of the Textile Foundation at the Bureau.

As reported in the May number of the *Journal of Research* (RP1587), a good qualitative relation was found among subjective tests, measure-

* Communicated by the Director.

ment of the drop in temperature which ensues when wet fabrics are placed on a skin surface, and tests to measure the extent of contact which the fabrics make with the skin. Fabrics which produced considerable chilling in subjective tests were found to make good contact and to cause a substantial drop in skin temperature. On the other hand, fabrics which caused little or no clamminess made poor contact, and the accompanying drop in temperature was relatively small.

From the results of these experiments on fabrics of a variety of constructions and fiber compositions, several important conclusions can be drawn. Thus, for example, the progressive improvement of the fabrics as their wool content is increased, and the superiority of some types of construction which minimize the extent of contact of the fabrics with the skin, are clearly indicated.

EFFECT OF HUMIDITY ON PHYSICAL PROPERTIES OF PAPER.

Paper is very sensitive to changes in the atmosphere, particularly to changes in relative humidity. As the atmosphere becomes humid, paper absorbs moisture which is given up again in dry air. Many of the physical characteristics or properties of paper are altered by this ebb and flow of moisture. The extent to which various papers are affected by given amounts of change in atmospheric humidity and temperature has been determined.

A rather extensive study of this character was made a number of years ago at the Bureau, but unfortunately the report of this work has long been out of print. The essential data are being published again as Circular C445 by Frederick T. Carson. This contains a number of tables and graphs which show the variation with humidity of the weight per unit area, the bursting strength, the tearing resistance, the folding endurance, the tensile strength, and the stretch to failure in tension. This information is supplemented by a number of references to other published reports on the same subject.

Copies of C445 are obtainable from the Superintendent of Documents, Government Printing Office, Washington, D. C. The price is 5 cents.

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INFLUENCE OF METALLIC DRIERS ON LINSEED-REPLACEMENT OILS.

With the object of conserving drying oils used in protective coatings, the War Production Board, through its Conservation Order M-332 as amended October 6, 1943, specified the maximum amount of certain oils allowed in the formulation of paints, varnishes, etc., for civilian use. The quantities set forth in this order are appreciably lower than the amounts customarily used in such commodities. Linseed-replacement oil, consisting of bodied linseed oil, raw linseed oil, and thinners, with

or without driers, was designed as a complete vehicle to replace linseed oil in the adjusted formulations necessitated by the order. Federal Specification TT-P-371, as amended March 17, 1944, covers two types of linseed-replacement oils—Type I oil contains driers, whereas no driers are added to Type II oil.

Fifty oils of known composition were prepared, and the effect of various metallic driers on their clarity, kauri reduction, acid number, and set-to-touch time was studied.

In general, driers lower the percentage of kauri reduction that this type of material will withstand. Drier combinations containing the same amount of the respective metals give similar results whether they are of the same type or a mixture of types. Lead driers cause the least change in kauri reduction values, and manganese driers the greatest, with the values of cobalt falling in between. Lead-cobalt driers yield higher kauri reduction values than do either lead-manganese or cobalt-manganese driers. Increasing the amount of drier within reasonable working limits tends to decrease the percentage of kauri reduction the oil will withstand. On the other hand, the set-to-touch time is somewhat shortened.

Manganese driers, when used alone, appreciably increase the acid value of the oil, whereas very little change is effected when they are used with lead or cobalt driers or combinations of the two. Lead driers separate from the oil in a relatively short time. The presence of small amounts of calcium tends to hold the lead in solution but does not necessarily insure against its separation.

A bodied oil of high acid value may be expected to have a higher kauri reduction than one of the same viscosity, which has a low acid value. Either mineral spirits, turpentine, or a mixture of these may be used as a thinner for replacement oils without changing their properties except for slight variations in their viscosities.

PERMEABILITY OF CONCRETE TO KEROSINE.

The increased wartime use of concrete tanks for storing diesel oils, light fuel oils, and gasoline induced the Bureau to undertake a limited investigation of methods for rendering concrete adequately impermeable to these products. Measurements were made by F. B. Hornibrook of the daily inflow of kerosine under a 12 ft. pressure head into one face of specially treated concrete discs.

The penetration of kerosine into 14-day old untreated concrete was relatively low, but after the concrete dried for 6 weeks the penetration was high. The use of integral admixtures and of lacquered instead of oiled forms reduced the penetration, but not enough to be economically adequate. Sodium silicate or magnesium fluosilicate applications were not significantly effective; but plain, well trowelled plaster coat of

cement-sand mortar reduced the rate of penetration of the kerosine to a low value. Whether the development of shrinkage cracks on a large surface treated in this manner would nullify these results remains a question. Powdered iron-type admixtures in the mortar coat reduced oil penetration, and one magnesium oxychloride type of coating looked promising if used where exposure to drying or to water is not excessive. This type of coating has the advantages of low cost and easy application. Spar varnish was effective in reducing penetration but would require long-time tests to indicate its permanence to such exposures. Polyvinyl chloride type paints and polysulfide emulsified latex linings were effective and are reasonably stable to water, oils, and gasoline. However, these materials are expensive and the cost of applying them is high, so that their use is warranted only under special conditions.

DETERMINING INDIVIDUAL HYDROCARBONS IN MIXTURES.

A paper by Anton J. Streiff and Frederick D. Rossini (RP1584) in the May *Journal of Research*, describes a general method for determining individual hydrocarbons in mixtures of hydrocarbons by measurement of freezing points. The method is based on the fact that the amount of a hydrocarbon H in an unknown mixture of hydrocarbons can be determined by measuring the lowering of the freezing point of a sample of pure H caused by the addition to it of a given amount of the unknown mixture. If the unknown mixture contains none of the hydrocarbon H, the lowering of the freezing point will have its greatest value, which will be substantially that called for by the ideal or dilute solution laws; whereas, if the unknown is composed entirely of the hydrocarbon H, the lowering of the freezing point will be zero.

In the exact application of the method, it is important to show that the solution of the hydrocarbon H with the unknown is, within the desired limits, ideal or sufficiently dilute, so that the ideal law of the lowering of the freezing point may be applied. If the solution of the hydrocarbon H with the unknown is not ideal or sufficiently dilute, it will be necessary to separate the unknown mixture beforehand by an appropriate fractionating process into two or more portions, each of which will form substantially ideal, or sufficiently dilute, solutions with the appropriate pure hydrocarbons.

Experimental data are given for determining each of the four C_8 aromatic hydrocarbons. The uncertainty of the determination of each hydrocarbon is near ± 1 per cent. of the total sample.

FREEZING AND MELTING CURVES OF HYDROCARBONS.

In RP1397 (*J. Research* NBS **26**, 591; June 1941), which deals with time-temperature freezing and melting curves obtained on hydro-

carbons, it was shown how, when significant undercooling occurs on freezing, the observations can be analyzed to yield, in proper relation to the subsequent equilibrium part of the curve, the "zero" time, that is, the time at which crystallization would have begun in the absence of undercooling. In that paper, visual extrapolation of the equilibrium part of the curve to "zero" time on freezing and to the corresponding time on melting was used to determine the freezing point, defined as the temperature at which an infinitesimal amount of crystals of the major component is in equilibrium with the liquid.

Now, William J. Taylor and Frederick D. Rossini, in the *Journal of Research* for May (RP1585) describe a method which may be used either analytically or graphically for extrapolating the equilibrium part of a time-temperature freezing or melting curve to give the freezing point, T_f, of the given hydrocarbon substance. A description is also included of a method for deducing, within certain wide limits, from the same observations on the given substance, if carried over a sufficiently large fraction of material crystallized or melted, the freezing point for zero impurity, T_{f_0}. When the heat of fusion is known or can be estimated, the value of $T_{f_0} - T_f$ serves to give an estimate of the amount of liquid-soluble, impurity in the given substance.

COMMERCIAL STANDARD FOR OIL-BURNING FLOOR FURNACES.

Commercial Standard CS113–44 for oil-burning floor furnaces has just been released. The standard was developed by the industry in cooperation with the Government on request of the Office of Price Administration. It sets forth definitions; requirements for construction, performance, laboratory tests, general installation, venting, publication of furnace ratings, informative labeling, and uniform wording of the manufacturer's guarantee; and gives the wording for the installer's certificate declaring compliance with the commercial standard.

These floor furnaces provide a simple effective means for automatic heat in areas where oil is normally plentiful. The entire unit is let into the floor between the joists to save living space which might otherwise be occupied by a space heater. Where oil-burning devices are permitted, the standard will provide a basis for guaranteeing effective performance and safety, and should insure fair competition.

The standard became effective for new production on February 17, 1944.

Copies of the pamphlet are available from the Superintendent of Documents, Government Printing Office, Washington, D. C., at 10 cents each.

ARMY AND NAVY NOTES.

Jet Propelled Aircraft.—(*Army Ordnance*, Vol. XXVI, No. 143.) Fighter airplanes employing jet-propulsion engines soon will be in production, having passed experimental tests successfully.

Jet-propulsion engines were originally of British design. Work was started on these engines in Great Britain in 1933 by Group Captain Frank Whittle. Full information about the engine was described in July 1941 to the United States Army Air Forces who at once asked for an engine to be sent to the U. S. A., and the engine which had made the first flight was sent to the General Electric Company in September 1941.

The first of these engines was ready for test in less than six months. At the same time the Bell Aircraft Company was given an order to build an aircraft suitable to operate with two of these engines, and the first flight in the United States was made in less than twelve months. Several hundred successful flights have been carried out since then by American pilots in the United States and by British pilots with British aircraft in England, many of them at high altitudes and with extreme speed and all without a single mishap.

The plane is still without an official public designation, but during the years of development it has been known variously as "Putt-Putt," "Squirt," "Hush-Hush," "Siberia," and "Super-Secret."

The prime difference in the outward appearance of the jet-propulsion plane in contrast with others is that it does not have a propeller. Once, when the plane was transported by truck from one testing site to another, a dummy wooden propeller was attached, successfully cloaking its identity.

R. H. O.

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THE FRANKLIN INSTITUTE.

MEDAL DAY PROCEEDINGS.

The Dinner Meeting and Presentation of Awards at The Franklin Institute began at five-thirty on the evening of Wednesday, April 19, 1944, in Franklin Hall. Mr. Charles S. Redding, President of the Institute, presided.

Reception to Medalists.

The exercises were opened by a reception to the Medalists, given by the Hostess Committee of The Franklin Institute. About six hundred persons were present. At six o'clock dinner was served in Franklin Hall.

At seven-forty-five the President announced: It is our custom in these war days to open our meetings with the playing of the National Anthem. Tonight we had expected to have with us Lt. Guy Marriner, of our staff, but now in the service, to play it for us on the piano. We had looked forward with much pleasurable anticipation to having Lieutenant Marriner with us again, but unfortunately at the last moment his orders were changed and tonight he is in Topeka, Kansas, instead of at The Franklin Institute in Philadelphia. When he notified us of this change in his plans he asked us to extend to you his best greetings and to express for him his regret that he cannot be with us. We are all looking forward to the time when Guy Marriner will be able to return to his Institute activities, particularly his much appreciated Sunday afternoon recitals. In view of this regrettable change in our plans, our National Anthem will be played over our public address system. Immediately thereafter the President called upon Mr. W. M. Vermilye, member of the Board of Managers and Chairman of the National Franklin Committee, to propose a toast to Benjamin Franklin. Mr. Vermilye responded and the toast (in water) was offered to Benjamin Franklin.

Stated Monthly Meeting.

The President announced that this was the regular monthly meeting of The Franklin Institute, that the minutes of the February meeting had been published in full in the March Journal and, if no objection were offered, they would be sustained. Upon motion they were declared approved as printed.

The President then greeted the assembly:

MR. REDDING: At this time will the sponsors of the 1944 medalists please occupy the chairs provided for them immediately in front of the head table.

Now that that bit of formality has been taken care of, it is my very real pleasure to greet this fine audience. Medal Day is always an outstanding event in the Institute year, and an occasion to which we look forward. It is the annual event at which the Institute, in the presence of a notable gathering, does honor to men and women who have distinguished themselves in the fields of Science and the Mechanic Arts. We are very happy to have you with us and on behalf of the Officers and Board of Managers of the Institute I bid you a hearty welcome.

Since the last Medal Day dinner 1,776 members have been elected to membership in The Franklin Institute. Our Membership Committee and the members of our staff working under the direction of that Committee have done an outstanding piece of work during the last two or three years in expanding our membership and thus spreading the influence of the Institute. We heartily welcome all these new members.

Forty of them are with us this evening. Will they be good enough to rise for a moment in order that we may all greet them? Thank you —we are delighted to have you with us.

FORMER MEDALISTS HONORED.

It is our custom to invite to these Medal Day meetings those who in previous years have received Franklin Institute medals. There are 32 former medalists here this evening. I will read their names in the chronological order in which they received their medals and will ask each medalist to rise as his name is called, and to remain standing until the complete list is called. Will the audience please withhold applause until the last name is announced.

FORMER MEDALISTS ATTENDING MEDAL DAY—1944.

Year of Award	Medalist	Medal
1904	Clamer, Dr. G. H.	Cresson
1905	Alteneder, Mr. Theodore G. [Representing Theodore Alteneder & Sons]	Longstreth
1920	Leeds, Mr. Morris E.	Longstreth
1921	Adams, Dr. Leason H.	Longstreth
1921	Bingham, Dr. Eugene C.	Certificate of Merit
1922	Weiss, Mr. John Morris	Potts
1923	Parks, Mr. Harry S.	Longstreth
1924	McBride, Mr. Thomas C.	Longstreth
1924	Sheen, Mr. Milton R.	Longstreth
1930	Chrisman, Mr. Charles S.	Wetherill
1931	Davisson, Dr. Clinton J.	Cresson
1932	Dashiell, Mr. Philip T.	Clark
1932	Wenner, Dr. Frank	Wetherill

Year of Award	Medalist	Medal
1934	Harvey, Dr. E. Newton	Wetherill
1935	Shrader, Dr. James E.	Wetherill
1936	Hall, Mr. Peter P. G.	Longstreth
1936	Hersey, Mr. Mayo D.	Levy
1937	Eksergian, Dr. Rupen	Henderson
1937	Erban, Mr. Richard T.	Longstreth
1937	Haug, Mr. John S.	Longstreth
1937	Whittemore, Mr. Herbert L.	Longstreth
1938	Ward, Mr. Alger L.	Levy
1939	DeJuhasz, Mr. Kalman J.	Levy
1939	Wilford, Mr. E. Burke	Certificate of Merit
1940	Williams, Dr. Robert R.	Cresson
1941	Wilson, Mr. Benjamin J.	Longstreth
1942	Larkin, Mr. Walter	Certificate of Merit
1943	Bull, Mr. Anders	Levy
1943	Urey, Dr. Harold C.	Franklin

MR. REDDING: May I recognize at this time the two men who have done and are still doing much for The Franklin Institute—our two living past presidents—Mr. Nathan Hayward and Mr. Philip C. Staples. Both of these men after having served faithfully and well as presidents of the Institute—each over a period of years—are still actively interested in the affairs of the Institute and are still giving freely of their time. May I ask Mr. Hayward and Mr. Staples to rise for a moment.

REPORT FROM THE SECRETARY.

It is part of the business of our Stated Meetings to have a report from Dr. Henry Butler Allen, Secretary of the Institute and Director of our Museum. Tonight Dr. Allen is to report to us upon the Institute's activities, particularly with respect to the part the Institute is playing in the winning of the war. Dr. Allen is a very busy man. In addition to directing what is left of the normal activities of the Institute, he is directing the war work which is being carried on here, and is also Deputy Chief of Division 1, National Defense Research Committee. Despite his current activities he is constantly finding time to be thinking and planning concerning the Institute's future. He is doing a fine job for us and I know that you are all anxious to hear his report. Dr. Henry Butler Allen:

Dr. Allen spoke as follows:

Mr. President—Honored Guests—Ladies and Gentlemen:

The Franklin Institute is fortunate in being able to contribute a *good deal* of itself to direct war research. About this, as you all understand, I have the same old story which has to be told by those engaged in certain kinds of war work—I can't say anything about it. But I *can* and do ask you to believe that eventually, perhaps not a year from

now, but soon, I hope,—we will tell you, and you *will* be rather proud of your Franklin Institute.

We are contributing also, less directly perhaps, but essentially, by continuing some of our educational activities. And if I can't tell you how *we* are "all in it" on direct war work—I can point out how *you* our Members and Friends, are "all in it" behind us—helping us, through these hectic days. For example—

You indicate approval of our medal activities by coming to us this Medal Day in far larger numbers than ever before, to some embarrassment to ourselves in our desire for your comfort.

In the past year you have attended our lectures by an average of 87 more each lecture.

You have asked our library for 2,600 more photostatic copies of technical literature than in the previous year.

More of you have visited our curtailed Museum and Planetarium.

You have continued, as individuals, or through your businesses, to help us financially by contributions to our Friends of Franklin and to our Industrial Coöperation.

More of you have been asking us about Franklin. Our telephone operator, for the first time this April first, had calls from people asking to speak to Dr. Franklin—they had received messages to call him at Rittenhouse 3050. But I must admit that this incident is a rather doubtful compliment to our National Franklin Committee.

Even our Board of Managers have bettered their attendance at Board meetings by 25 per cent.

Our good Hostess Committee are with us this evening—25 strong —just one example of their helpfulness.

And you have increased our membership by 1,776 in the past year —and so on.

It all makes us feel that perhaps we are maintaining the usefulness of The Franklin Institute, through these war times.

Now, I feel that I can boast a bit about these conditions because they are due to others than myself; for our staff at the Institute is made up of a splendid lot of loyal men and women; and our President and Board of Managers have given unselfish support.

PLANS FOR THE FUTURE.

I might mention one or two of our present thoughts for after the war. We hope to extend our research in the fields of applied science. We hope that this will furnish another way of being useful to industry, as well as to earn an honest penny for ourselves. We will need these pennies, and more. For as "Poor Richard" said, "'Tis hard for an empty bag to stand upright."

Another bit of post-war thinking—the period between 1947 and 1952 marks the 200th anniversary of Benjamin Franklin's electrical

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discoveries which the present-day scientist says were the foundation upon which our present-day electronics are built. We are giving thought to a proper celebration of that event—expecting that the war will be well over some time between those years.

But, meanwhile, we still have a desperate war to win. We can't let any considerations slacken our war effort. And we have good advice in one statement made by our Patron, Benjamin Franklin:

"The eyes of Christendom," said he, "are upon us, and our honor as a people is become a matter of the utmost consequence to be taken care of . . . Present inconveniences are, therefore, to be borne with fortitude, and better times expected."

MR. REDDING: Tonight, as we did last year, we are recognizing war conditions, with their attendant transportation difficulties, by combining our Medal Day ceremonies into one occasion. As many of you know, until last year it had been our time-honored practice to have two meetings on Medal Day; the first in the afternoon—a formal meeting of the Institute at which the medals were awarded; and then a dinner meeting, such as this—in honor of those who in the afternoon had been the recipients of medals. The attendance at last year's meeting and the enthusiastic comments concerning it, followed by an overflow meeting tonight, lead us to at least question whether we will ever return to a two-session Medal Day.

We are sorry that it was not possible to accommodate all of our guests in Franklin Hall during the dinner. When we planned this meeting we intended to limit the attendance to 400 but the responses to the invitation were so great that we just did not have the heart to stick to that decision. As a matter of fact there are 580 persons in attendance tonight which of necessity means discomfort to some. We appreciate the manner in which you have accepted this situation. This large attendance is an indication of the continuing and growing popularity of these Medal Day occasions.

COMMITTEE ON SCIENCE AND THE ARTS.

Last year I spoke at some length of the work of the Committee on Science and the Arts, which Committee is responsible for the painstaking work involved in the selection of those whose names are presented to the Board of Managers for the award of Medals. I will not repeat my comments of last year, but I do want to again pay tribute to that Committee. Again through its efforts, we have a notable list of men to whom we will pay honor.

AWARD TO RUSSIAN SCIENTIST.

During its long history The Franklin Institute has awarded eighty medals to scientists of foreign countries. Tonight we will award the

eighty-first. That medal, a Franklin Medal, our highest honor, will be awarded to a scientist of Russia. That will be quite an appropriate award—for several reasons. I wonder how many present are acquainted with the fact that Benjamin Franklin was a member of the Imperial Academy of Sciences, St. Petersburg? Those who were not acquainted with that fact will be interested in the following letter of Nov. 4, 1789, from Princess Ekaterina Romanovna Dashkova to Benjamin Franklin:

"Dear Sir:—Having always supposed, and even cherished the idea, that you were a member of the Imperial Academy of Sciences, which is at St. Petersburgh under my direction, I was greatly surprised, when, reviewing the list of its members some days ago, I did not find your name in the number. I hastened therefore to acquire this honor for the Academy, and you were received among its members with an unanimous applause and joy. I beg you, Sir, to accept of this title, and to believe that I look upon it as an honor acquired by our Academy.

"I shall order the patent to be dispatched to you as soon as possible. In the meantime be assured, that it is with the greatest pleasure that I profit of the present occasion to give you token of my regard and veneration for your eminent character, and that I shall always recollect with pride the advantage I had to be personally noticed by you. With a sincere consideration I am, dear Sir, your most obedient servant, PRINCESS OF DASCHKOFF."

At a meeting of The Franklin Institute last November a Russian film was shown, "Glimpses of Russian Science." This was in coöperation with the American-Russian Institute in Philadelphia. At that time The Franklin Institute sent the following message to Professor Vladimir Komarov, President, Academy of Sciences of the USSR, Moscow, Russia:

"American traditions mark Benjamin Franklin the scientist, the diplomat, the Ambassador of good will and friendship among nations.

"The Franklin Institute of Philadelphia in coöperation with the American Russian Institute at a stated meeting held November 17, 1943, viewed with keen interest an unique Russian sound film showing glimpses of soviet science, physical, chemical, and physiological experiments of high attainments.

"This month marks the 154th anniversary of Benjamin Franklin's election to membership in the Russian Academy of Sciences. The Franklin Institute takes this occasion, in the spirit of Benjamin Franklin, to send greetings to the scientists of the Soviet Union, with the belief that the interrelations of the arts and sciences between our two great countries will greatly further mutual understanding, good will, and permanent peace."

Although I had nothing to do with this award except as a member of the Board of Managers passing upon the recommendation of the Committee on Science and the Arts, it is of particular interest to me. In 1938 the recipient was carrying on his work in England at Cambridge University. That year I was in London and was fortunate enough to

be invited to attend a meeting of the Royal Society. The speaker at that meeting was the same man who tonight will be honored by the Institute. He made a lasting impression upon me, but little did I think then that in a later year I would have the honor to hand to him, through the Russian Ambassador to the United States, the highest award of The Franklin Institute.

While we regret that the recipient cannot be here, we have the privilege and the honor of having with us His Excellency Andrei Gromyko, Ambassador of the Union of Soviet Socialist Republics. Although he is overwhelmed with affairs of State, the Ambassador, realizing the importance of Science, and because of the high position accorded the recipient of the medal in his own country, has taken the time to come to Philadelphia to present the greeting of his fellow-countryman and to receive on his behalf the Franklin Medal which will be duly forwarded in the diplomatic pouch. We shall have the honor of hearing from the Ambassador later.

AWARD OF MEDALS.

Mr. Redding then called upon the first sponsor, Mr. Edward L. Forstall.

MR. FORSTALL: Mr. President: Telegraph messages must often be received and repeated by operators at one or more intermediate points, as direct wires are commercially possible only between large centers with heavy traffic.

Relaying by hand involves expense, delay and possibility of error.

A mechanized method of relaying, known as the Reperforator Switching System, developed by the Western Union Telegraph Company and in use in Richmond, Virginia, is an important improvement in telegraph practice.

The system uses perforated tapes, and automatically transfers messages from receiving to transmitting apparatus, with only momentary attention of an attendant to connect them.

It represents ingenious application of old principles to development of new apparatus and methods.

The Western Union Telegraph Company is recognized for this important contribution to telegraphy by award of a Certificate of Merit, upon citation reading:

"For the development of the Reperforator Switching System, a contribution to the greater accuracy and speed of telegraphic service."

I present Mr. A. N. Williams, President of that Company, to receive the award on its behalf.

MR. REDDING: Mr. Williams, by virtue of the power vested in me as President of The Franklin Institute, I have the honor to hand you herewith this Certificate of Merit together with a copy of the report which accompanies it.

I next recognize Mr. Frank H. Rogers.

MR. ROGERS: Mr. President: In pumping water or other liquids containing sand, ashes, gravel and other abrasive materials by centrifugal pumps, difficulties have been experienced due to wear of the seals resulting in leakage and rapid decrease in efficiency and quantity of water pumped, with frequent shut-downs and high maintenance costs.

In 1932, Mr. Frank B. Allen of Philadelphia developed a centrifugal pump known as the Hydroseal pump, in which a supply of clear flushing water is admitted to the chambers between the stationary and revolving parts under sufficient pressure to prevent entry of the abrasive materials into those spaces, thereby greatly reducing wear of the pump seals.

Hydroseal pumps for handling such abrasive materials have been used widely throughout the United States and other countries.

The citation in this case, for award of an Edward Longstreth Medal, reads as follows:

"In consideration of the development of a pump which will successfully handle water or liquids containing abrasive materials, retain its initial efficiency and original discharge for considerable periods, with low maintenance costs, and the successful manufacture of this type of pump, giving satisfactory operation in many installations."

I present Mr. Allen.

MR. REDDING: Mr. Allen, by virtue of my office as President of The Franklin Institute, I present to you the Edward Longstreth Medal together with a copy of the report.

I recognize Mr. Francis G. Tatnall.

MR. TATNALL: Mr. President: The Candidate I present is honored by the Institute for a valuable contribution to engineering and research.

The parts of all structures and machines, from largest to smallest, are subject in service to compression, tension, bending and torsional strains.

Their accurate measurement is of fundamental importance in engineering design, in performance testing, and in research to attain better ways of doing things.

Stress analysis is based on assumptions. Our Medalist supplies an extremely convenient means for checking their accuracy.

His device, small as a postage stamp but large in usefulness, affixed like a stamp by cement to a member to be tested, picks up the strain and registers it accurately on a remote electric recorder.

It is used in many engineering fields to measure service stresses, particularly in places previously impossible under service conditions.

It has proven essential in engineering design of aircraft and other powerful instruments of war, and will be as valuable in peace.

Upon citation reading:

"In consideration of his development of a strain gage involving the use of fine wire, bonded to the surface under investigation by means of

plastic, whereby the change in length is readily measured by the change in electrical resistance of the wire, which device has come into widespread use as an engineering tool."

It is my pleasure to present Edward E. Simmons, Jr., for award of an Edward Longstreth Medal.

MR. REDDING: Mr. Simmons, I have the honor to present to you this Edward Longstreth Medal and certificate which accompanies it. I want to express to you our sincere appreciation for the long journey you have taken to be with us today.

The next sponsor is Mr. Charles H. Masland, 2nd.

MR. MASLAND: Mr. President: Your Committee on Science and the Arts, believing that engineers, whose achievements are more dependable than most prophesies, should not, like prophets, go without honor in their own country, and seeing in J. Stogdell Stokes of our own city a man honored for his patronage of art, finds him also deserving of honor for his engineering contribution to the manufacture of articles coming almost daily into our homes, the humble paper boxes of innumerable conveniences.

Although used in great quantities, they were made on crude machines with much handwork, until Mr. Stokes designed and made automatic machines for quantity production with a minimum of handwork.

I present Mr. Stokes, upon citation, reading:

"In consideration of his development of paper box manufacturing machinery and his leadership of his organization in that field."

MR. REDDING: Mr. Stokes, by reason of the power vested in me as President of The Franklin Institute, I am delighted to have this privilege of presenting to a distinguished Philadelphian our Edward Longstreth Medal.

I now call upon Mr. Coleman Sellers, 3rd.

MR. SELLERS: Mr. President: I have the honor of presenting a Medalist who has contributed to human health.

Air conditioning systems in office buildings, schools, auditoriums and other places in which many people gather have contributed to their comfort by control of temperature, humidity and dust, but have left many of the bacteria in the air to be recirculated.

Our Medalist devised a practical system for introduction of special light tubes in the air ducts, emitting bacteria killing ultra-violet rays, killing a high percentage of bacteria in the circulated air, thus reducing spread of infection.

Other similar and valuable uses are in dairies, food and drug packaging plants and like places where the purity of product may be improved, and in hospital rooms where danger from infection may be greatly reduced.

It is, therefore, an especial pleasure, upon citation reading:

"In consideration of his application of a source of bactericidal ultraviolet radiation in air conditioning systems in a scientific and practical manner,"

to present Harvey Clayton Rentschler for award of a Frank P. Brown Medal.

MR. REDDING: Dr. Rentschler, by reason of my office as President of The Franklin Institute, I am very happy to present to you the Frank P. Brown Medal and the report which accompanies it.

May we hear Mr. Ralph H. McClarren.

MR. MCCLARREN: Mr. President: The candidate whom I am about to present has provided a means of increased convenience and more extensive use for man's benefit of x-rays in the fields of metallurgy and medicine.

Their uses for medical purposes are probably more generally known than are their important uses in metallurgy. One such very important use is in testing materials such as thick metal castings for hidden flaws making them unsuitable or unsafe for intended purposes.

Such use was limited, however, by location of the testing apparatus in a fixed position because of the large size and great weight of the high voltage supply equipment.

That situation the present Medalist has greatly relieved by the invention and development of a voltage supply for a 1,000,000 volt x-ray apparatus of portable type which can be taken to the work; thereby greatly extending its usefulness.

Your Committee on Science and the Arts, upon citation reading:

"In consideration of his development of a successful high-voltage, low frequency resonance transformer of relatively small size and light weight, which is shock-proof, efficient in operation and particularly suitable for use in the high voltage portable x-ray unit,"

presents to you, Sir, Mr. Willem Fredrik Westendorp of the General Electric Company's Research Staff as recipient of the Institute's John Price Wetherill Medal.

MR. REDDING: Mr. Westendorp, I hand you the John Price Wetherill Medal and the report which accompanies it and wish to express our pleasure in having you with us today.

The Chair now recognizes Mr. Lionel F. Levy.

MR. LEVY: Mr. President: It is my sad but from the standpoint of deserved recognition a happy privilege to present the recommendation of the Committee on Science and the Arts for a posthumous award of a John Price Wetherill Medal to the late Richard C. duPont for his development of a practical "on the wing" airplane pick-up device; known as Air Mail and Glider Pick-Up.

His untimely death intervened between the Committee's investiga-

tion and formulation of its report, and it therefore recommended a posthumous award in his honor for his great service to air transportation.

Large and fast planes require such large landing and take-off fields that smaller communities cannot afford to provide them.

Mr. duPont realized that they could be rescued from air isolation, and air transportation be vastly increased if airplanes could pick up mail and express while in flight.

Pioneering, he overcame many difficulties and developed a device by which airplanes in full flight can pick up substantial poundage; even gliders with pilot aboard having been picked up and towed to their destination.

Resulting increase in air mail and express mileage and pick-up figures are impressively prophetic of future expansion; and military uses are yet to be revealed.

The Medal, in recognition of Mr. duPont's development of this device so greatly increasing the possibilities of air transport, is awarded upon the following citation:

"In consideration of his development of a successful and practical 'on-the-wing' air mail and glider pick-up apparatus."

It is my privilege to present Mrs. duPont, who is graciously present to receive the medal, in honor of her late husband.

MR. REDDING: Mrs. duPont, by power vested in me as President of The Franklin Institute, I hand you herewith Medal and report awarded posthumously to your honored husband. I wish also to express to you our deep appreciation for your kindness in coming here this evening to help us pay to him this well-deserved public recognition.

The next sponsor, Dr. Rupen Eksergian.

DR. EKSERGIAN: Mr. President: The late George R. Henderson, a distinguished railway engineer and long a member of the Committee on Science and the Arts, provided in his will the foundation for award by the Institute of a medal "for meritorious inventions or discoveries in the field of railway engineering."

The Medal, named in his honor, has been awarded since its foundation in 1924, to such eminent engineers that it has become recognized as a high distinction.

Your Committee, after careful survey and consideration of men prominent in the Railway Engineering field, recommends award of this Medal to Joseph B. Ennis, Senior Vice-President and Director of Engineering of the American Locomotive Company, upon the following citation:

"In consideration of his accomplishments in locomotive engineering and important contributions in the field of locomotive design."

I present Mr. Ennis.

MR. REDDING: Mr. Ennis, by virtue of my authority as President of The Franklin Institute, I hand you herewith the Henderson Medal and the report which accompanies it.

CLAMER MEDAL AWARD.

Tonight, for the first time, The Franklin Institute awards the Clamer Medal for "meritorious achievement in the field of Metallurgy." This medal was founded some years ago under the terms of the will of Francis J. Clamer, a distinguished metallurgist, co-founder of the Ajax Metal Company, and father of our own Dr. G. H. Clamer, also outstanding in the field of metallurgy, now President of the Ajax Metal Company, a member of our Board of Managers, and as has been previously announced, the recipient in 1904 of the Institute's Cresson Medal. The award of the Clamer Medal was originally placed in the hands of the Technical Society of Philadelphia, but was awarded only once by that Society. That award was made in December 1935. The Society disbanded in 1939. Through the efforts of Dr. Clamer the funds and the administration of that award were, through the Courts, placed last year in the hands of The Franklin Institute. The medal is of silver and is to be awarded not less often than once in five years.

I now call on Dr. Clamer who is sponsor for the gentleman to receive this award.

DR. CLAMER: Mr. President: I am privileged to present a Medalist who is honored by The Franklin Institute for his contributions to metallurgical arts and sciences, particularly blast furnace operation, during his many years of devotion to their advancement.

His achievements in those fields, which have advanced him to a high position not only in business but also in esteem of his fellow scientists, have been marked by progressive rather than revolutionary advances.

Especially notable has been his elimination of uncertainties and consequent lack of close control in blast furnace operation, and his development of more scientific methods and better control, with achievement of uniformity of iron and steel not previously attainable.

The vast and diversified uses of these metals make the value of such close control very obvious.

It is an especial pleasure to me to present the recipient for the first award by The Franklin Institute of a medal lately placed at its disposal which was originally founded by my father.

I present Dr. Mathesius, upon recommendation of the Committee on Science and the Arts as follows:

"The Francis J. Clamer Medal is for meritorious achievement in the field of Metallurgy.

"Your committee, by unanimous agreement, recommends that the first award of that Medal under the jurisdiction of The Franklin Institute be made to

Dr. Walter Emil Ludwig Mathesius
of Geneva, Utah

for his long continued, sound and beneficial influence on the development of metallurgy of iron and steel, and particularly for his contributions in the field of blast furnace practice."

MR. REDDING: Dr. Mathesius, it is with great pleasure we bestow upon you this important Medal. We welcome you as its first recipient in The Franklin Institute and wish to express our deep appreciation for your kindness in making the long journey to receive it in person.

I now call upon Mr. Eugene W. Boehne.

MR. BOEHNE: Mr. President: The Medal named in honor of the late Louis Edward Levy, for many years a faithful and active member of the Committee on Science and the Arts, is awarded annually to the author of a paper of especial merit published in the JOURNAL OF THE FRANKLIN INSTITUTE, preferably one describing important experimental and theoretical researches by the author.

Stephen P. Timoshenko, Professor of Theoretical and Applied Mechanics at Stanford University, Palo Alto, California, is recommended for this award for the year ending last September, for his paper, "The Theory of Suspension Bridges," which appeared in the March and April, 1943, issues of the JOURNAL.

It is a distinct contribution to the practical theory of supension bridges and presents analytical developments of an original character. It also considers suspension bridges having continuous stiffening trusses, a type which although not extensively used in this country may come into greater use because of economies claimed for them.

As Professor Timoshenko is not able to be present this evening, due to distance and his present work, I read the citation for the Louis Edward Levy Medal which will be sent to him:

"For his paper on 'The Theory of Suspension Bridges' which appeared in the March and April 1943 issues of the JOURNAL."

MR. REDDING: Mr. Secretary (Dr. Henry Butler Allen, Secretary of The Franklin Institute), will you be good enough to see that this Medal and the accompanying report are sent to Professor Timoshenko.

I recognize Mr. John Morris Weiss.

MR. WEISS: Mr. President: I have the honor to present a scientist who has been for over three decades one of the foremost investigators in the field of organic chemistry.

Of particular interest and importance are his work on local anesthetics, his classical investigations of Chaulmoogra oil, used in the treatment of leprosy, and investigations of a wide variety of other naturally occurring substances which have aided progress in medicine.

Those and other researches have been of unusual importance in advancing both the theoretical and the practical sides of his science.

As head of the Chemistry Department of the University of Illinois since 1926, he has had great influence upon chemical education.

At present, on leave from there, he is serving on the National Defense

Research Committee of the Office of Scientific Research and Development.

With great pleasure I present, upon citation, reading:

"In consideration of his signal contributions in the field of Organic Chemistry, which have resulted in important extensions of its frontiers," Professor Roger Adams, as recipient of an Elliott Cresson Medal.

MR. REDDING: Dr. Adams, by virtue of my office, I present to you with my personal congratulations the Elliott Cresson Medal and the certificate and report which accompany it.

We now come to the awarding of our Franklin Medals and I call upon Dr. Frederic Palmer, Chairman of the Sub-Committee for the Franklin Medal, to introduce the Franklin Medalists of the evening: Dr. Palmer.

DR. PALMER: Mr. President: The people of the United States have to thank Doctor Coolidge for saving them an annual electric lighting bill of over three billion dollars. Thirty years ago he began a study of electric lamp filaments which at that time were made of carbon and provided poor illumination at considerable cost. He found that filaments of tungsten would be much more satisfactory, if only they were not so brittle. After years of discouraging research he discovered how to make tungsten, naturally one of the most brittle of metals, into one so ductile that it can be drawn down to a filament of diameter one-sixth that of a human hair. Such filaments in our lamps today give us brilliant illumination at a small cost.

The x-ray tube of twenty-five years ago was a feeble and capricious instrument. Neither the quantity nor the quality of the output of x-rays was under ready control of the operator. Doctor Coolidge devised a tube in which a pure electron stream from a hot tungsten filament was projected through a high vacuum against the target. Accelerating voltage and filament current are separately under complete control making the duplication of dosage a simple matter. Exposures which formerly required minutes now require seconds. Doctor Coolidge has improved other parts of x-ray equipment adapting it for use in industry and in the arts. In the field of medicine his improved x-ray equipment has brought relief to untold millions of patients all over the world.

Hence "in recognition of his contributions to the welfare of humanity, especially in the field of the manufacture of ductile tungsten and in the field of improved apparatus for the production and control of x-rays," it gives me pleasure to present

William David Coolidge, Vice president and Director of Research of The General Electric Company, Schenectady, New York.

MR. REDDING: Dr. Coolidge, by virtue of the power vested in me as President of The Franklin Institute, I have the honor and the pleasure of presenting to you the Franklin Medal and a certificate of

honorary membership in The Franklin Institute, together with a copy of the report of the findings of our Committee on Science and the Arts.

Dr. Coolidge, after expressing his pleasure in receiving this outstanding honor, then delivered his paper entitled "The Rapidly Expanding Field of Usefulness of the X-Rays." *

MR. REDDING: Dr. Palmer, will you be good enough to read the citation for our other distinguished Franklin Medalist of today.

DR. PALMER: Mr. President: Doctor Kapitza's most important work has been the invention of a new method of producing fields of magnetic force of an intensity many times greater than were previously thought possible. This he accomplished by sending an alternating current of approximately 30,000 amperes through a coil of wire which lacked the usual iron core, and limiting the current flow to one-half cycle, or a duration of about 1/100 second. Thus excessive heating of the coil by such an enormous current was prevented by reducing the time of current flow to a small fraction of a second.

In order to investigate the changing properties of magnetic materials placed in these powerful fields it was necessary to devise entirely new experimental techniques by means of which accurate measurements of these properties could be made in less than 1/100 of a second.

The results which he achieved through his brilliant experimental techniques were no less brilliantly interpreted in his contributions to the field of theoretical physics.

Doctor Kapitza has also made important advances in the field of low temperatures. He devised improved apparatus for making liquid hydrogen and also for making liquid helium, and he discovered that liquid helium II has the property of super-fluidity, that is, of flowing with extraordinary ease. He found the coefficient of viscosity to be less than one hundred millionth that of water at a temperature of 20° Centigrade.

"In recognition of his remarkable contributions to experimental physics and also to theoretical physics, especially in the fields of magnetism and low temperatures," I take especial pleasure in presenting to you, Sir, as a candidate in absentia for the Franklin Medal a great scientist, the citizen of a great country to which this country is closely allied,

Peter Kapitza, Director, Institute for Physical Problems, Academy of Sciences, Union of Soviet Socialist Republics.

In the absence of Dr. Kapitza, his Excellency, the Honorable Andrei Gromyko, Ambassador from the Union of Soviet Socialist Republics to the United States, has kindly consented to receive the Medal in his behalf.

* Dr. Coolidge's paper, "The Rapidly Expanding Field of Usefulness of the X-Rays," appears on page 435 of this issue.

MR. REDDING: Your Excellency, it gives me great pleasure, by virtue of my office, to bestow upon your distinguished countryman the Franklin Medal and certificate of honorary membership in The Franklin Institute. We are extremely conscious of the honor you do us by coming here from Washington to accept this award on behalf of Dr. Kapitza. We shall be grateful if you will see that the Medal and reports are forwarded to him through the diplomatic pouch.

AMBASSADOR GROMYKO: I am very happy to be present today at this meeting gathered on the occasion of handing of medals by The Franklin Institute, awarded to outstanding scientists, among whom is my compatriot, Dr. Kapitza. I am also glad to transmit friendly greetings from Soviet scientists to all those present here. The bestowing of such a great award, the Franklin Medal, to a Soviet scientist symbolizes not only the recognition of scientific achievements of Kapitza but is a demonstration of friendship between the American and Soviet scientists as well.

The achievements of American science are also recognized by Soviet scientists. A good example of this is the honorary membership accorded to seven American scientists by the Academy of Sciences of the U.S.S.R., and the corresponding membership extended to eight other American scientists.

It is regretted that, in view of being exceedingly busy and due to difficulties of wartime communication, Dr. Kapitza could not come to this country to attend this meeting. He asked me to accept in his behalf the awarded to him medal and to read his following message:

"I am very sorry that the circumstances of wartime do not permit me to take advantage of the courteous invitation of The Franklin Institute and to accept personally the high award with which the Institute has honored my scientific works.

"Such a high valuation of my scientific works by the American learned public opinion is extremely flattering to me. I am deeply touched to receive the medal of Benjamin Franklin—a man whose name is dear to us from high-school days and whom we are used to respect as one of the greatest builders of world science and culture.

"Franklin for us is not only the originator of the unitarian theory of electricity but also a scientist who strived to combine science with life and who understood the whole meaning of electrical phenomena for the progress of mankind. Besides Franklin was also a great citizen defender of freedom and culture.

"In these days when our countries have united for the purpose of struggle for freedom and culture the memory of such people like Franklin must be especially dear to us and must inspire us in our united efforts.

"The requested by you article about my works will be forwarded to you without delay, but due to difficulties of postal communications during wartime it may arrive late.

"A short account of this article was forwarded to you by cable."

MR. REDDING: Thank you Mr. Ambassador. We shall now have a reading of a synopsis of Dr. Kapitza's paper which he was good enough to send by cable and which was translated for us by the Embassy. I wish to present Dr. James Barnes, Technical Adviser of The Franklin Institute.

DR. BARNES: Mr. President, Your Excellency, Ladies and Gentlemen: I hold before me two papers from the Russian Embassy in Washington. They arrived in Philadelphia this morning just in time for our Medal Day exercises. That is what I call Soviet military precision.

Let me read you the first paper.

April 18, 1944

Dear Sir:

I am forwarding herewith a short summary of the article by Dr. Kapitza which is on its way to the United States, but which due to wartime difficulties in postal communications has not arrived yet.

Sincerely yours,
(signed) V. BAZYKIN
First Secretary

The President and the Board of Managers
The Franklin Institute
Philadelphia, Pennsylvania

It is now my happy privilege to read the synopsis of Dr. Kapitza's paper.* I think you will all agree with me, especially the many distinguished physicists who are with us this evening, that Dr. Kapiza's paper when published in the JOURNAL OF THE FRANKLIN INSTITUTE will be an outstanding contribution to science. In the vernacular of the day "I think he has got something."

The meeting adjourned with the playing of one verse of "America," at 9:40 P.M.

* The synopsis of Dr. Kapitza's paper, "Super-Fluidity of Helium II and Attainment of the Absolute Zero," appears on page 441 of this issue.

STATED MONTHLY MEETING, MAY 17, 1944.

When the guests were assembled, the President introduced Lieutenant Guy Marriner, member of the staff of The Franklin Institute, who was in Philadelphia on a short leave, and asked him to make a statement to the audience regarding his work in the Army.

After briefly outlining the part which music is playing in the rehabilitation of the men in the Armed Forces, Lieutenant Marriner opened the meeting by playing the National Anthem.

Mr. Redding, the President, then called the meeting to order and after announcing that this is the last stated monthly meeting of The Franklin Institute for the season, called attention to the fact that minutes for the March meeting had been published in full in the April number of the JOURNAL and would stand approved as printed if there were no corrections. The minutes were so approved.

Dr. Henry Butler Allen, Secretary, then reported that since the last meeting the following additions to Membership had been made:

Sustaining	1
Active	85
Non-Resident	8
Associate	34
Student	19
Library Sustaining	4
Total	151
Total membership now is	5,783

He expressed the appreciation of the officials of the Institute to the membership for its splendid participation in the Medal Day exercises when nearly 600 attended.

The President called to the attention of the meeting, the fact that those present were participating in a very important function, namely the inauguration of the Charles Day Lectures which are to be given annually in May.

In reviewing Mr. Day's career, he stated that he was a graduate of the University of Pennsylvania, an organizer of the firm of Dodge & Day, later President and then Chairman of the Board of Day & Zimmerman, Inc.; a director of the Pennsylvania Railroad, the Fidelity-Philadelphia Trust Company, and the United Gas Improvement Company—Active in many civic projects, charged with many important responsibilities during the first World War, an eminent engineer, an exponent of scientific management, an author of engineering and management books and papers—he was easily one of Philadelphia's outstanding citizens. He was particularly interested in The Franklin Institute, having been on its Board of Managers from 1908 to the time of his death in 1931, a period of twenty-three years. For three of those years he served as a Vice-President.

The Charles Day Foundation was established a few years ago by Mrs. Margaret Day Truitt, widow of Charles Day when, for herself and her children, she formally endowed a lectureship in his memory, the lectureship to embrace the various phases of engineering and management in which Mr. Day was interested.

The President then introduced the lecturer of the evening, Morris Llewellyn Cooke, Sc.D., Consulting Engineer in Management. Dr. Cooke had been selected to give the first lecture on the Charles Day Foundation because of his former close association with Mr. Day, as well as for his own outstanding list of accomplishments and the high position he attained in public life and his own chosen field.

Dr. Cooke was Director of Public Works under Mayor Blankenburg and during the first World War served as Chairman of the Storage Committee of the National Defense Council, was a member of the Depot Board of the Army, and Chairman of the Organization and Methods Branch of the Emergency Fleet Corporation. In 1942 and 43 he was Head of the American Technical Mission to Brazil and has held many other important positions because of his wide knowledge and eminence as an engineer. He is the author of a number of books and papers and the recipient of many honors both in this country and abroad.

Dr. Cooke addressed his audience on "Some Commanding Aspects of the American Man of Business." His paper will be printed in full in the August issue of the JOURNAL.

The meeting adjourned at 9:30 with a rising vote of thanks to the Lecturer. Many members of the audience however stayed for further informal discussion with Dr. Cooke. The meeting was finally closed at 10 P.M.

COMMITTEE ON SCIENCE AND THE ARTS.

(Abstract of Proceedings of Stated Meeting held Wednesday, May 10, 1944.)

HALL OF THE COMMITTEE,
PHILADELPHIA, MAY 10, 1944.

MR. WILLIAM B. COLEMAN *in the Chair.*

The following report was presented for final action:

No. 3122: Strain Analysis through Brittle Lacquers.

This report recommended the award of a Certificate of Merit to Greer Ellis, of Chicago, Illinois, "For his work in the development of brittle lacquers for strain measurements and in establishing a technique which makes possible a more dependable quantitative interpretation of the indications."

LIBRARY NOTES.

The Committee on Library desires to add to the collections any technical works that members would wish to contribute. Contributions will be gratefully acknowledged and placed in the library. Duplicates received will be transferred to other libraries as gifts of the donor.

Photostat prints of any material in the collections can be supplied on request. The average cost for a print 9 × 14 inches is thirty-five cents.

The library and reading room are open on Mondays, Tuesdays, Wednesdays and Fridays from nine o'clock A.M. until five o'clock P.M., Thursdays from nine o'clock A.M. until ten o'clock P.M., Saturdays nine o'clock A.M. to twelve o'clock noon.

RECENT ADDITIONS.

AERONAUTICS.

LANGEWIESCHE, WOLFGANG. Stick and Rudder. 1944.

BIOGRAPHY.

BATHE, GREVILLE, AND DOROTHY BATHE. Jacob Perkins. 1943.

CHEMISTRY AND CHEMICAL TECHNOLOGY.

COITH, HERBERT. So You Want to be a Chemist? 1943.

EPHRAIM, FRITZ. Inorganic Chemistry by P. C. L. Thorne and E. R. Roberts. Fourth Edition—Revised. 1943.

EYRING, HENRY, JOHN WALTER, AND GEORGE F. KIMBALL. Quantum Chemistry. 1944.

HALLIDAY, EVELYN G., AND ISABEL T. NOBLE. Food Chemistry and Cookery. 1943.

MOJONNIER, TIMOTHY, AND HUGH CHARLES TROY. The Technical Control of Dairy Products. Second Edition. 1925.

Organic Reactions. Volume 2. 1944.

U. S. Bureau of Internal Revenue. Gauging Manual. 1938, 1939.

ELECTRIC ENGINEERING.

COCKRELL, W. D. Industrial Electronic Control. First Edition. 1944.

KOEHLER, W. A. Principles and Applications of Electrochemistry. Volume 2: Applications. Second Edition. 1944.

ENGINEERING.

CHELLIS, ROBERT D. Pile-Driving Handbook. 1944.
JOHNSON, WALTER C. Mathematical and Physical Principles of Engineering Analysis. First Edition. 1944.

FORESTRY.

Society of American Foresters. Forestry Terminology. 1944.

GEOGRAPHY AND TRAVEL

MCGUIRE, PAUL. Westward the Course. 1942.

GEOLOGY.

ENGELN, O. D., VON. Geomorphology. 1942.

LANGUAGE.

BODMER, FREDERICK. The Loom of Language. 1944.

MANUFACTURES.

KELLY, HAROLD C. A Practical Course in Horology. 1944.

MATHEMATICS.

DEMING, W. EDWARDS. Statistical Adjustment of Data. 1943.
DIMICK, CHESTER E., AND CUTHBERT C. HURD. Mathematics for Mariners. 1943.
NORTHROP, EUGENE P. Riddles in Mathematics. 1944.

MECHANICAL ENGINEERING.

BRADFORD, LOUIS J., AND GEORGE L. GUILLET. Kinematics and Machine Design. 1943.
HUDSON, WILBUR G. Conveyors and Related Equipment. 1944.

MILITARY SCIENCE.

BLISS, GILBERT AMES. Mathematics for Exterior Ballistics. 1944.
LOBECK, A. K., AND WENTWORTH J. TELLINGTON. Military Maps and Air Photographs. First Edition. 1944.

NAVIGATION AND NAVAL ARCHITECTURE.

ALDEN, CARROLL STORRS, AND ALLAN WESTCOTT. The United States Navy. 1943.
BAKER, ELIJAH, III. Introduction to Steel Shipbuilding. First Edition. 1943.
BRANCH, W. J. V., AND E. BROOK-WILLIAMS. A Short History of Navigation. 1942.
SHUTE, WILLIAM GEORGE, AND OTHERS. An Introduction to Navigation and Nautical Astronomy. 1944.
STEWART, JOHN Q., AND NEWTON L. PIERCE. Marine and Air Navigation. 1944.

PHOTOGRAPHY.

Society of Motion Picture Engineers. The Technique of Motion Picture Production. 1944.

PHYSICS.

CAMPBELL, PERCY A. Why the Universe? 1943.
DÉVÉ, CHARLES. Optical Workshop Principles. 1943.
RAWLINGS, A. L. The Theory of the Gyroscopic Compass. Second Edition. 1944.

RAILROAD ENGINEERING.

JOHNSON, RALPH P. The Steam Locomotive. Second Edition, Revised and Enlarged. 1944.
Model Railroader Cyclopedia. 1944. Fifth Edition. 1943.

NOTES FROM THE BIOCHEMICAL RESEARCH FOUNDATION.

An Extension of Dawson's Table of the Integral of e^{x^2}.—H. M. TERRILL AND LUCILE SWEENY. While the integral of e^{-x^2} has been extensively tabulated because of its connection with the theory of probability, the integral of e^{x^2} has received comparatively little attention. A tabulation over a limited range is given by H. G. Dawson (*Proceedings of the London Mathematical Society*, **29**: 521, 1898).

This function is useful in evaluating certain integrals which arise in mathematical physics and which can be made to depend on it. It is also involved in certain other functions of importance. Thus Kapzov and Gwosdower (*Zeitschrift fuer Physik*, **45**: 114, 1927) mention the function $xe^{-x^2}\int_0^x e^{x^2}dx$ in connection with short wave oscillators, and give a small table of values. Sakamoto (*Saechsische Akademie der Wissenschaften Sitzungsberichte*, **80**: 217, 1928) gives a four place table of the function $e^{-x^2}\int_0^x e^{x^2}dx$ which appears in the theory of heat conduction.

Dawson's table extends only from $x = 0$ to $x = 2$ and in some cases it is desirable to know the values of the integral over a greater range. It is the object of the present work to extend Dawson's table to $x = 4$.

In preparing the table given below, the method followed consisted in first computing by direct methods the values of the function for twenty-two key arguments, differing by 0.1, and then filling in the values for the intermediate arguments by Gregory's formula.

For the direct computation, there are two series available, and both were employed, checking against each other. The first is the one given by Dawson, and the second is that obtained from the uniformly convergent exponential series by termwise integration, i.e.,

$$\int_0^x e^{x^2}dx = x + \frac{x^3}{3} + \frac{x^5}{5\cdot 2!} + \frac{x^7}{7\cdot 3!} \cdots \text{ etc.}$$

Since this series is the same as the series for the probability integral, save for the signs of alternate terms, only half the terms are needed. The terms of odd rank are computed, and from twice the sum of these the appropriate value of the probability integral is subtracted.

For the intermediate arguments, where the integral was computed in terms of difference functions, the form of Gregory's formula adapted to receding differences was used. In the early part of the work, differences were taken to the fourth order, and in the later part, to the sixth order.

x	$\int_0^x e^{x^2}dx$	x	$\int_0^x e^{x^2}dx$	x	$\int_0^x e^{x^2}dx$
2.00	16.45263	2.35	60.55820	2.70	296.5942
2.01	17.00970	2.36	63.12063	2.71	311.6533
2.02	17.58961	2.37	65.80691	2.72	327.5512
2.03	18.19344	2.38	68.62359	2.73	344.3379
2.04	18.82229	2.39	71.57758	2.74	362.0666
2.05	19.47732	2.40	74.67621	2.75	380.7940
2.06	20.15977	2.41	77.92720	2.76	400.5803
2.07	20.87093	2.42	81.33872	2.77	421.4896
2.08	21.61214	2.43	84.91943	2.78	443.5899
2.09	22.38484	2.44	88.67847	2.79	466.9538
2.10	23.19052	2.45	92.62549	2.80	491.6585
2.11	24.03077	2.46	96.77075	2.81	517.7861
2.12	24.90723	2.47	101.1250	2.82	545.4242
2.13	25.82165	2.48	105.6998	2.83	574.6659
2.14	26.77587	2.49	110.5073	2.84	605.6105
2.15	27.77182	2.50	115.5602	2.85	638.3636
2.16	28.81153	2.51	120.8722	2.86	673.0379
2.17	29.89714	2.52	126.4577	2.87	709.7535
2.18	31.03090	2.53	132.3319	2.88	748.6382
2.19	32.21519	2.54	138.5110	2.89	789.8284
2.20	33.45250	2.55	145.0121	2.90	833.4697
2.21	34.74548	2.56	151.8533	2.91	879.7170
2.22	36.09688	2.57	159.0540	2.92	928.7359
2.23	37.50964	2.58	166.6345	2.93	980.7027
2.24	38.98684	2.59	174.6163	2.94	1035.8058
2.25	40.53173	2.60	183.0226	2.95	1094.2462
2.26	42.14772	2.61	191.8775	2.96	1156.2384
2.27	43.83843	2.62	201.2070	2.97	1222.0115
2.28	45.60767	2.63	211.0384	2.98	1291.8098
2.29	47.45945	2.64	221.4007	2.99	1365.8947
2.30	49.39802	2.65	232.3249	3.00	1444.5451
2.31	51.42784	2.66	243.8437		
2.32	53.55366	2.67	255.9919		
2.33	55.78043	2.68	268.8065		
2.34	58.11343	2.69	282.3267		

The computation was started at $x = 1.90$ to enable a check to be made with some of Dawson's results. We note the following correction here: for $x = 1.92$ we find for the value of the integral 12.70733 instead of Dawson's value 12.703175. In the actual computation, the work was carried to ten or more significant figures for the key arguments, and to seven places beyond the decimal point for the intermediate ones, except at the extreme end of the table. The values were finally rounded off to five places or less.

For larger values of x, the asymptotic series given by Stieltjes (*Acta Mathematica*, **9**: 167, 1886) is usually satisfactory. Thus for $x > 4$, the asymptotic series gives the value of the integral to better than seven significant figures.

x	$\int_0^x e^{x^2}dx$	x	$\int_0^x e^{x^2}dx$	x	$\int_0^x e^{x^2}dx$
3.00	1444.5451	3.35	11750.8431	3.70	124149.07
3.01	1528.0591	3.36	12524.4399	3.71	133304.41
3.02	1616.7551	3.37	13351.8098	3.72	143164.92
3.03	1710.9735	3.38	14236.8676	3.73	153787.04
3.04	1811.0782	3.39	15183.8250	3.74	165231.90
3.05	1917.4582	3.40	16197.2138	3.75	177565.68
3.06	2030.5295	3.41	17281.9112	3.76	190860.08
3.07	2150.7370	3.42	18443.1673	3.77	205192.78
3.08	2278.5567	3.43	19686.6342	3.78	220647.98
3.09	2414.4978	3.44	21018.3984	3.79	237316.91
3.10	2559.1053	3.45	22445.0150	3.80	255298.49
3.11	2712.9623	3.46	23973.5455	3.81	274699.97
3.12	2876.6933	3.47	25611.5979	3.82	295637.65
3.13	3050.9668	3.48	27367.3708	3.83	318237.69
3.14	3236.4988	3.49	29249.7006	3.84	342636.95
3.15	3434.0559	3.50	31268.113	3.85	368983.95
3.16	3644.4598	3.51	33432.880	3.86	397439.85
3.17	3868.5907	3.52	35755.077	3.87	428179.61
3.18	4107.3918	3.53	38246.652	3.88	461393.16
3.19	4361.8744	3.54	40920.493	3.89	497286.78
3.20	4633.1223	3.55	43790.509	3.90	536084.47
3.21	4922.2980	3.56	46871.707	3.91	578029.58
3.22	5230.6479	3.57	50180.288	3.92	623386.53
3.23	5559.5094	3.58	53733.745	3.93	672442.63
3.24	5910.3168	3.59	57550.964	3.94	725510.20
3.25	6284.6097	3.60	61652.343	3.95	782928.74
3.26	6684.0402	3.61	66059.917	3.96	845067.41
3.27	7110.3818	3.62	70797.493	3.97	912327.69
3.28	7565.5385	3.63	75890.798	3.98	985146.28
3.29	8051.5552	3.64	81367.637	3.99	1063998.26
3.30	8570.6280	3.65	87258.069	4.00	1149400.63
3.31	9125.1160	3.66	93594.594		
3.32	9717.5541	3.67	100412.359		
3.33	10350.6661	3.68	107749.380		
3.34	11027.3800	3.69	115646.785		

A manuscript copy of the table, which gives some additional information, has been deposited in the library of Brown University. We wish to thank Prof. Carl J. Rees, of the University of Delaware, for encouragement and suggestions given during the course of the work.

BOOK REVIEWS.

KINEMATICS AND MACHINE DESIGN, by Louis J. Bradford and George L. Guillet. 357 pages, illustrations and tables, 14 × 20 cms. New York, John Wiley & Sons, Inc., London, Chapman & Hall, Limited, 1943. Price $3.00.

One feature which often distinguishes a modern textbook is its direct and simple approach to the subject. Much of the unessentials such as mathematical proofs and excursions into border-line subjects have been eliminated in the interest of brevity, and the resulting course of study is much more "stream-lined" and condensed. The book at hand illustrates this fact. It is the abridgement and consolidation of two texts—Kinematics of Machines, by G. L. Guillet and Machine Design, by L. J. Bradford and P. B. Eaton.

The general procedure is first definition, then explanation, then application and problems. The book is divided into two parts, the first being devoted to kinematics. Here, under the heading of General Considerations, are given definitions and, when necessary, worked out examples thus acquainting the student at the outset with the method of treatment. Following this in order are the topics: velocities in mechanisms, slider-crank mechanisms, rolling contact, cam mechanisms, and then a number of miscellaneous mechanisms are grouped. Theories are outlined in a practical way.

Part II is the larger part of the text. It treats on machine design, but before entering into the discussion proper on the process of the design of a machine, the more important of the terms frequently used are defined. Then beginning with the topics of friction, lubrication, and bearings the treatment is directed to function clutches and brakes, shafts and couplings, screws and screw fastenings, gears and gear trains, belts and chains, springs, flywheels, flatplates, cylinders, and weld construction. At the end there are given fifteen drafting room problems and a number of useful tables. There is a subject index for reference purposes.

The treatment is characterized by worked out examples throughout. At the end of chapters are practical problems for exercise and the answers to many are given. The book is useful as a text for students, as a refresher for engineers and as a reference.

R. H. OPPERMANN.

ENZYME TECHNOLOGY, by Henry Tauber. 275 pages, photographs and illustrations, 14 × 22 cms. New York, John Wiley & Sons, Inc., London, Chapman & Hall, Limited, 1943. Price $3.50.

The production of various compounds with the aid of microörganisms offers the most fascinating problems. Some of these problems have been solved to the point of putting the organisms to work on a factory scale. Ever since Pasteur utilized this method there has been a growth of knowledge along these lines and of recent years a great increase in products of fermentation. The outlook now is an unlimited field for catalytic microörganisms and practical enzymology.

The role and use of enzymes in industry, their preparation and their use in medicine is the coverage of this book. Reflecting the present position of the industry, the book starts out with a discussion on the relation to yeast production and utilization, the production of ethyl alcohol and the role of enzymes in brewing. Mold fermentations and bacterial fermentations, followed by the production of enzymes and methods for their estimation, are next taken up. Enzymes for medical use is a heading under which a review is made not only of the use but of experimental progress. Special attention is given to enzymes of grains and malt, and the role of enzymes in bread baking, in dairy products, and in the meat, egg, vegetable and fruit industries. The part that enzymes play in other industries is also given space, including such

industries as paper, leather, textiles, tobacco. Microbiological methods for the estimation of vitamins are discussed and the procedures are given.

The book is in the form of a monograph, the basic material being drawn from a large number of references from a broad literature field. It is well composed, and presented in an orderly fashion with a variety of illustrations. In the back there is an author and subject index which adds to its value for reference purposes. The world is ready for an up-to-date account of the entire field of enzyme technology as well as detailed knowledge in any one part or industry.

R. H. OPPERMANN.

SO YOU WANT TO BE A CHEMIST, by Herbert Coith. 128 pages, 13 × 19 cms. New York, McGraw-Hill Book Company, Inc., 1943.

What is a chemist? This little book describes some of the different kinds of work in which a chemist and chemical engineer take part, the kinds of chemists industry wants and the kinds of industries chemists want. It explains something of the characteristics that help make the chemist valuable, also some of the qualities that handicap him. The conclusion is reached that the chemist is a human being who is going to be welcomed in more and more fields of business activity and industry as people learn more about him and as he in turn learns more about people.

The subject matter is interesting to read and should clarify the answers to questions entering the minds of young people preparing themselves for careers in industrial chemical work. Men in business may also learn from this book how chemists work, what they do and what can be expected of them.

R. H. OPPERMANN.

WHY THE UNIVERSE? Or, Cosmopoietic Space, by Percy A. Campbell. 189 pages, 16 × 24 cms. San Francisco, George Fields, 1943. Price $2.50.

The author of this book here offers evidence that the universe lacks extrinsic elements and therefore it is scientifically rational throughout. It is the argument that space and the universe are one and the selfsame thing. He treats not only the evolutional what and how of the universe, but also its evolutional why and wherefore.

In the beginning an outline is made of evolution applied to stages of organization and of functioning which leads from neutron to proton, from proton to atom, from atom to molecule, from molecule to organic living cell, and from the living cell to the finished organism, man. The discussion then is directed to matter and space, in which physical space is envisioned as differing from Euclidean space in many ways. The idea is brought out of a spacewarp or unit of matter wherein physical space is supposed to be somewhat granular in ultimate constitution. A unit of radiation or radiant energy is next taken up, together with an electrical aspect, both being very closely bound to each other. These three—matter, radiation and electricity—are modes of spatial abnormality which feature the universe. From here and in this manner the march of evolution is built up through the 92 chemical atomic elements, then the numerous kinds of inorganic and organic molecules, and lastly, the living organisms and non-living bodies of matter in general.

The theory is well presented, although the flowery language used in many places tends to becloud the viewpoint which is sought. Undoubtedly much plainer language would help the patience of many readers, especially those who are in disagreement, in part or in total, with the author.

R. H. OPPERMANN.

PUBLICATIONS RECEIVED.

Selected Papers of William Frederick Durand, Reprinted in Commemoration of the Eighty-fifth Anniversary of his birth. V.P., 22 × 28 cms. The Durand Reprinting Committee, California Institute of Technology, 1944. Price $2.50.

Infrared Spectroscopy, by R. Bowling Barnes, Robert C. Gore, Urner Liddell and Van Zandt Williams. 236 pages, drawings and tables, 16 × 24 cms. New York, Reinhold Publishing Corporation, 1944. Price $2.25.

20th Century Engineering, by C. H. S. Tupholme. 201 pages, photographs and illustrations, 15 × 23 cms. New York, Philosophical Library, 1944.

Systematic Inorganic Chemistry, by Don M. Yost and Horace Russell, Jr. 423 pages, drawings and illustrations, 16 × 23 cms. New York, Prentice-Hall, Inc., 1944. Price $4.60.

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CURRENT TOPICS.

ARMY AND NAVY NOTES.

" Lost Wax Process " Used for Casting Airplane Equipment.—Complicated parts for the turbo-superchargers that make possble high altitude bombing over Germany are now being made by a modern adaptation of a process used for centuries by sculptors. Known as the "lost wax process," it was described by the 16th Century Italian artist, Benvenuto Cellini. In those days it was mainly employed with bronze, and other metals of relatively low melting point.

In recent years, in the dental laboratories the process has been improved, so as to make it applicable to alloys of high melting point, which retain their strength and hardness at high temperature. As further developed by R. H. Thielemann of the General Electric Research Laboratory, it has proved particularly suited for making buckets of the gas turbines which drives the turbo-supercharger of bombing planes, such as the Flying Fortress. These turbines are propelled by the exhaust gases from the engines, and operate at red heat. The materials of which the turbine buckets are made, because they are so strong at high temperatures, are necessarily hard to forge or to machine.

The new version of the "lost wax process" started with a wax pattern, formed by hand to the exact shape desired. This was invested in a plaster cast. When the plaster hardened it was heated; the wax melted out, and there remained a mold that followed exactly all the intricacies of the wax. It was not necessary to separate the mold to remove the pattern, so complicated designs, with many undercuts, could be reproduced. Molten metal was poured into the cavity and allowed to cool and harden. Then the plaster was broken away, and the result was a replica in metal of the wax pattern.

Plaster can be used with low melting point metals, such as lead, tin, brass, copper, gold and the other "noble" metals. It does not, however, stand the high temperatures required to melt iron, steel, and the new hard alloys. The dental laboratories and also Mr. Thielemann and his associates developed mold materials suitable for metals with melting points well above 3000° F. The G-E. scientists devised electrically controlled machines which can produce thousands of accurate wax patterns. Other new equipment was devised for each operation in the precision casting process.

First, a metal master pattern of the part to be cast is made, with proper allowance for the shrinkage of the cast metal. This is used to cast a split lead alloy mold which is provided with dowel pins to assure accurate mating. If necessary, this may be separated in several pieces, or it may contain inserts for complicated parts.

Next the lead alloy mold, clamped together, is placed in the wax injection machine. There is a partial vacuum around the mold, and the melted wax is forced into the cavity under pressure, so it reaches all parts of the mold. When the wax has cooled, the mold is removed, and opened. Several wax patterns made in this way can be combined, by heating them where they join, and more complicated pieces made.

The wax pattern is dipped into a suspension of fine silica flour in a liquid binder. When this is hard, the coated patterns are placed in a metal container and the mold material, of graded silica sands with a binder, is poured around them. This is allowed to set. Then the molds are placed upside down in an oven heated to about 250° F, which melts the wax so that it runs out. Next the molds are placed in a furnace and heated to about 1650° F, to make them ready for the casting operation.

In one method of casting, the molten metal is forced into the mold by compressed air. Another does it with centrifugal force, the molds being rapidly spun so that the molten metal is thrown into them. After casting, the molds are allowed to cool, after which they are broken open to remove the cast metal part.

R. H. O.

Flak Helmets for Flyers.—(*Army Ordnance*, Vol. XXVI, No. 143.) A new fashion headgear, being worn by combat crews of the Army Air Forces, has been developed and is being produced by the Army Ordnance Department. Some members of bombardment crews, in performing their specific duties, have more room in the aircraft than others. As a result, two types of steel helmets have been developed. One, the M3, was developed by the Ordnance Department, the other, the M4, was developed by the Air Forces. Both types of helmets, however, are being produced by Army Ordnance.

The M3 fits over the regular leather helmet worn by flyers. It has protecting steel flaps to cover the earphones and these flaps are attached to the body of the helmet by hinges. When the steel helmet is put on, the flaps are held up so they do not interfere with the earphones, which protrude slightly. The flaps are then lowered over the earphones and held in place by a strap under the chin.

Extremely low temperatures are encountered in high-altitude flying, and a coating of flock is sprayed on the helmet to prevent a flyer's skin from freezing to the metal should he touch the new headgear. Flock is a substance similar to cotton lint or peach fuzz.

M4 type helmets were developed by the Air Forces. They are made of shaped plates to fit the different contours of the head, and are enclosed in a canvas cover. This helmet, which resembles a skull cap, also fits over the regular flying helmet. M3 helmets can be worn by most of the members of the bombardment crew, but the M4 is primarily for those who man the guns in the turrets, where space is very limited. These helmets are for protection against low-velocity fragments from anti-aircraft shells, and head injuries have been reduced considerably since the crews of combat aircraft have been wearing them.

R. H. O.

Army Cooking and Heating Units.—(*Heating and Ventilating*, Vol. 41, No. 5.) "Camouflage discipline" is constantly practiced by Army troops in or near the front lines. One of the surest indications of an otherwise well camouflaged position is the appearance of a light or flame at night. In the daytime, smoke from fires is like a sign post advertising the whereabouts of troops.

Even soldiers in combat must have hot food occasionally, and fires to warm themselves. The problem has been to furnish them with cooking and heating units that could be hidden from enemy eyes and burn with invisible smokeless flame. In active theaters of operation, soldiers' food is cooked over a gasoline range known as the M-1936. Mounted three abreast in trucks, these ranges are moved up to the front lines from protected areas under cover of darkness. Hot food is served directly into the men's mess kits. Breakfast is prepared and served before daylight. Then the kitchen trucks move to the rear for another load of hot food.

Utilization of the model gasoline range has not been without its problems. Although the M-1936 worked perfectly on the white unleaded gasoline available in this country, the heavily leaded aviation and motor gasolines found in combat zones clogged the fuel filters. It was necessary to develop new type filters and tests have shown these to be many times more efficient than the ones they replaced.

Another problem was overcome when a vacuum system was developed to prevent the gasoline from flooding the burner mixing chamber at low temperatures. The blue gasoline flames are not visible to enemy eyes but the flooding of the chamber often resulted in dangerous and easily seen fires. Special down-draft burners using fuel oil, kerosene or gasoline have recently been developed and these will become available in quantity to our fighting men within the next few months. Tests have shown them to be practical in use and free from smoke. Continued experiments are being carried on to improve ease and operation of control, ease of maintenance, fuel economy and durability.

Other types of heaters and ranges developed by the Quartermaster Corps for use by our troops include a midget model, weighing less than 1½ lb., made especially for soldiers alone or in small groups. Then there is a new immersion type water heater which is placed directly in the can of clear water used for rinsing mess kits. It heats the water more quickly than models placed under the can and consumes less fuel. It operates on gasoline, fuel oil or kerosene and gives off no visible flame. It is contained inside its own can for moving and saves 50 per cent. in weight and space.

R. H. O.

Refrigeration Retards Age Hardening of Aluminum Alloys.—F. KELLER. (*Heating and Ventilating*, Vol. 41, No. 5.) Some aluminum alloys, particularly those used for rivets and other aircraft parts, undergo significant changes in strength and workability on aging at ordinary temperatures for several days, after the parts were heat treated. The increase in strength that occurs is desirable and important but it is accompanied by a corresponding decrease in workability.

It has been general practice to heat treat aluminum alloy rivets or parts and then to head or form them within a period of one hour or less after quenching. Any rivets or parts that were not driven or formed within this period soon became too hard for working and had to be heat treated again. This was an uneconomical and inconvenient practice. It has been eliminated largely through the use of refrigeration.

For rivets the heat treatable alloys 175 to 245 are in general use. For both of these alloys, age hardening is practically complete after four days' storage at room temperature. As the storage temperature is lowered, age hardening is retarded. Thus, for example, at a temperature of 32° F., substantially little hardening occurs in a period of 16 hours, after which hardening starts and progresses slowly over a period of two weeks. When a storage temperature of 0° F. is employed, age hardening is completely retarded for a period of one week or more. At still lower temperatures, hardening would be entirely retarded over a much longer period.

In employing refrigeration practices for retarding hardening, it is important that the rivets or other parts be quenched rapidly and chilled as quickly as possible to the low temperature employed for storage. Thus, it is advantageous to use refrigerated quenching baths and rapid chilling units. For all practical purposes, a storage temperature of 0° F. is satisfactory for 175 and 245 alloys although some plants use temperatures of −30° F. and lower. Although the lower temperatures provide a wider margin of safety, the rivets are more difficult to handle when very cold because they tend to stick to the workman's fingers and tend to form frost from moisture in the atmosphere. In some instances, the rivets after quenching are given an alcohol rinse to remove residual water and prevent the rivets from sticking together when they are chilled. They may be stored in kerosene, alcohol or mixtures of these liquids to obtain rapid chilling and uniform maintenance of temperature.

R. H. O.

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Rodometric Examination of Quartz Crystals.—GERALD J. HOLTON. (*Electronics*, Vol. 17, No. 5) One of the important steps in the production of quartz "crystals" is the determination of the position and polarity of the axes, the "handedness" of the mother crystal, and the presence of twinning. Particularly in the case of crystals that have no well developed natural faces this usually necessitates a somewhat lengthy procedure, with several steps involving the use of a number of different instruments by several workers, each checking one of the characteristics in turn.

Attempting to improve a shorter method of orientation originally proposed by de Gramont, Professor W. J. Cady of Wesleyan University began in 1939 an investigation which was followed by further development by Mr. H. H. Hubbell. At the suggestion of Professor Cady and with his constant advice the author took up further investigation late in 1940, developing the proposed method of orientation.

It is now possible for a single worker to determine simultaneously in one operation the following facts concerning a given mother crystal of any size or shape, regardless of the absence of natural faces:

(a) Right- or left-handedness.
(b) Position of Z (optical) axis.
(c) Position of X and Y axes.
(d) Polarity of axes.
(e) Presence and kind of twinning at the etched surface.

The accuracy of orientation of the axes depends somewhat on the skill of the worker and the time taken for the observation. Two minutes manipulation

by a trained man may fix all axes within a fraction of a degree, and 15 seconds manipulation by an unskilled worker may result in an error up to 2 degrees. Though this so-called rodometric method has been used successfully in commercial practice as a substitute for x-ray orientation methods, more usually it serves to orient the mother crystal for the first cut within about a degree. Any necessary vernier adjustments in the orientation of the mounted crystal on the saw table are made by means of the usual x-ray data obtained from the first cut.

Another aim that has been realized is the simplicity and uniformity of the procedure. It is not necessary for the operator to make any dial settings, take readings or remember numerous conventions regarding the enantiomorphy of quartz or polarity of axes.

The process begins with a preliminary inspection of the crystal between polaroids, and the preparation of a small etched surface ("window") on the mother quartz. The crystal is then mounted on a swivel fixture after a brief optical check. Crystal and fixture are transferred to an instrument called a rodometer where the complete determination of characteristics is made optically in one step. Then the crystal is remounted for the saw-table and is ready for cutting. There is no intermediate cutting, and only one remount is needed.

R. H. O.

Chemically Transmuted Wood.—A staff report in *Chemical and Engineering News*, Vol. 22, No. 9, states that Urea, which assisted materially in transforming plastics from utility material into decorative items of many-hued brilliance, is again widening the plastics horizon. At least it will if a chemically transmuted wood, outlined recently by J. F. T. Berliner of the Ammonia Department in New York, blossoms into full maturity. This development by DuPont chemists follows research that parallels studies conducted by the Forest Products Laboratory of the U. S. Department of Agriculture.

Through impregnation with methylolurea, plentiful and inexpensive woods may be hardened, worked, polished, and through introduction of suitable dyes, colored throughout.

When sufficiently treated, the product has properties fundamentally different from wood. It loses its natural tendency to swell, shrink, or warp with humidity changes, and the grain will not rise on wetting.

Methylolurea-treated or transmuted wood differs from untreated wood somewhat as steel differs from iron. It may require slower rates of sawing, cutting and turning, different tool settings, harder tools, or more frequent sharpening of tools than untreated wood. Because of its increased hardness and density, more power is required to drill holes and insert screws or drive nails. However, the screw and nail-holding strength is higher than for untreated wood.

The methylolurea treatment appears applicable to almost all items manufactured from wood. Perhaps the most effective commercial procedure is the so-called "full cell" or vacuum pressure impregation process. The wood is placed in a chamber and the air withdrawn. The treating solution is introduced in sufficient quantity to cover the wood and allow for the volume of solution which will be absorbed. The chamber is then opened to the atmos-

phere or air pressure applied. After a determined period the solution is drained off and the wood removed for drying. For small items, centrifugal impregnation may warrant consideration.

A water solution of an uncondensed methylolurea is employed. This may be obtained by reacting urea and formaldehyde in the proper proportions and under controlled conditions. However, a simpler method is merely to dissolve urea in dimethylolurea (DMU in water). For most purposes 1 to 2 parts of urea and 6 parts of DMU dissolved in 20 to 24 parts of water are satisfactory.

R. H. O.

Seven Tons of Carbon Dioxide Guards Naval Stores from Fire. (*Compressed Air Magazine*, Vol. 49, No. 5.) A carbon dioxide fire extinguishing installation in the Aviation Material Storehouse of the Naval Storage Depot in Philadelphia, Pa., protects every part of that building, which is 577 x 119 x 17 feet in dimensions. The storehouse is one of a dozen buildings at the Philadelphia depot. It is divided by concrete and steel walls into four spaces which are connected by self-closing fire doors. In the rooms are stored paints, oils, greases, glues, dopes, lacquers, and other flammable liquids of which large quantities are required for airplane use. They present an enormous fire hazard, and the means that have been set up to safeguard them constitute what is termed the largest built-in carbon-dioxide fire extinguishing system in existence.

The system consists of a central supply of carbon dioxide, of piping to deliver it to all parts of the four rooms, and of nozzles to discharge it. The carbon dioxide in liquefied form is contained in 280 steel cylinders, each of which holds 50 pounds. Upon release, it becomes gaseous, expanding to 450 times its original volume, and the entire 7 tons can be directed by valves into any one of the four spaces. It is claimed that such a blanket would smother even the fiercest fire in a few seconds. The cylinders are manifolded in five frames containing 56 each, one acting as a master control frame. There are four valve-frame assemblies, each having five automatically actuated directional valves which, in the event of fire, send the gas to the particular space involved. Because of the importance of stopping the circulation of air in the presence of fire, each valve frame has two plunger type switches that are operated by the valves—one to close a circuit and to sound an audible alarm and the other to open a second circuit that stops the ventilating fans and shuts the louvers so that air will not feed the flames.

Five supply lines lead from the valve-frame assemblies to each of the four protected spaces, where they terminate in a total of 296 shielded discharge nozzles which are designed to deliver gas without any high velocity jet effect to prevent objectionable turbulence, forming a blanket that is built up from the floor.

Spotted about the ceilings at regular intervals are 48 heat actuators that become active when the temperature in the rooms exceeds a predetermined point. Heated air rises to the ceiling and, if of sufficient intensity, expands the air in the actuators, causing pressure waves to pass through tubing to a release mechanism located at the directional valves.

R. H. O.

Whitest of Whites.—(*Scientific American*, Vol. 170, No. 6.) From one of the blackest of black substances, silmenite, comes the whitest of whites which is also the ninth commonest element in the earth's crust. Between breakfast and bedtime everyone is sure to handle at least one object containing this substance—which is titanium.

Although titanium is an important ingredient in such everyday things as fabrics, linoleum, refrigerator enamels, paper, and white paint, as recently as World War I it had scarcely any commercial value and even today is chemically among the lesser known elements. Yet among the thousands of chemical compounds manufactured by du Pont, it is one of the most versatile.

Titanium dioxide is a white powder, so fine that 16 million individual particles of it side by side would measure only one inch long.

It is used by the armed forces in the protective creams that safeguard skin against painful flash burns inside gun turrets, and in other creams that offer protection against sunburn and insects in the tropics.

This same titanium dioxide, as an ingredient of the coating for welding rods, assists in maintaining a steadier arc and in improving the weld.

Titanium dioxide is handling a job in the field of paper manufacture that affects all of us at the present time. Wartime needs for paper are so great that the government asks for waste paper for salvage. Books and magazines are printed on thinner paper. Even the writing paper you buy today is thinner.

A few years ago it would have been difficult or impossible to use such thin paper, because the print or writing would have "shown through" from the back. But titanium dioxide, added to paper, keeps this from happening and so conserves paper—makes it go further.

It is titanium dioxide which gives present day white paints their extraordinary whiteness and hiding power, and the lighter colors their clarity and resistance to fading. Many peacetime products such as white rubber and the best white leather depend for their whiteness on titanium dioxide. White buckskin, for example, is pigmented in the tanning operation with titanium which is so fine that the particles go all the way through.

R. H. O.

Transmutation of Wood. (*Nature*, Vol. 153, No. 3888.) Attention is directed to what is claimed to be a new chemical treatment which makes wood nearly as hard as steel, transmuting it into a new material, part wood and part plastic. From the brief description given, it appears that this new material is only one of the many forms of what has become known as 'improved wood.' Until specimens have been examined it is not possible to verify the claims. In preparing a material of this kind it is, in general, sought to improve the strength properties and the dimensional stability of wood by a combination of impregnation with synthetic resins and densification under heat and pressure. The manner of effecting this varies from process to process. It was believed for some years that the use of synthetic resins was essential for the production of improved wood, but only recently the U. S. Forest Products Laboratory has demonstrated that much of what is done by the earlier processes can be achieved through the use of heat and pressure alone.

In the use of synthetic resins for making 'improved wood,' most success has been achieved with the phenol-formaldehyde type. Hitherto the amino resins have not been favored for the manufacture of improved wood, presumably because they have been found to be chemically not so stable as some other types and to have somewhat inferior ageing characteristics under warm and humid weather conditions. It is stated that the monomer combines with the natural acids in the wood; but the more conventional view of the setting process would appear to be that these acids merely behave like all other acids which are known to catalyse the setting reactions in urea/formaldehyde resins. The two claims which it will be most interesting to confirm are that almost any species of timber can be treated—particularly as nothing is said as to the thickness of piece which can be treated—and that all dimensional change is prevented. So far as existing experience goes, this latter claim seems to be incompatible with the implied retention of the best other properties of wood. Should these claims hold good after a period of years, the process will mark a big advance in the field of wood-plastic composites.

P.

X-Ray Diffraction Unit Uses Low-Angle-Scatter Camera. Readily solving analysis problems which formerly were considered impossible in the chemical, metallurgical and scientific fields, a new X-ray diffraction unit has been perfected that does the job in a non-destructive manner.

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X-ray diffraction is not new in itself. However, the utilization of new accessories and techniques now available will prove invaluable in the following fields: Welding, casting, forging, ferro-concrete, plastics, asphalt, oil, armaments, aircraft, locomotives, coal, leather, textiles, ceramics, chemical, plywood, steel valves, high pressure tanks, porcelain, cables, rubber, food (cheese, ice cream), rope, precious stones, and radio.

The new X-ray diffraction unit has a four-windowed tube enclosed in a massive bronze housing. Diffraction patterns of four different specimens can be obtained simultaneously. A number of types of X-ray tubes can be provided, included in which are targets of tungsten, molybdenum, cobalt, iron, chromium and copper.

Fully shockproof and rayproof, the unit utilizes full wave rectification which permits higher output and longer life from the tube. Filament current supply is stabilized, control of kilovoltage and milliamperage is smooth and stepless, tube is protected automatically if water supply fails, equipment has start-stop pushbutton control, and provision is made for use of automatic exposure timer.

The slanted panel is indirectly lighted for easy observation and carries, in addition to controls mentioned above, a 0–50 milliampere meter, main line switch with overload circuit breaker, calibrated peak-kilovoltage selector, and a pilot lamp. There is also an elapsed-time meter (calibrated in hours and tenths of hours) that serves for long exposures and for recording tube life.

P.

Electronics as a Measurement Tool. (*Industry and Power*, June 1944.) Development of the electronic tube has made possible many measurements

which were undreamed of formerly, and it has greatly simplified many measurements previously made in a cumbersome or expensive fashion. Electronic instruments are becoming more and more prominent in their contributions to our store of knowledge, as daily they are permitting engineers to design and build better and less expensive products.

Excessive vibration is destructive to high-speed rotating machines, such as propulsion equipment for destroyers and submarines, and superchargers for aircraft. The engineer must be able to measure accurately the degree of vibration and to make corrections of weight distribution to assure smooth, prolonged operation. Vibration indicating instruments have been available for many years, but with the electronic vibration velocity meter, measurement and analysis of vibrations can be made more accurately and at higher speeds.

Sound measurement is another example of the contributions which electronics has made to industrial measurements. Before the development of the electronic tube, the measurement of sound was solely by ear, without any definite standards against which to measure.

Electronic equipment has helped in many complicated industrial problems. An example of this is the analysis of gas where it is desired to have a continuous indication and a running record of gas concentrations in a furnace or a pipe line.

An electronic mercury-vapor detector has been produced to give an instantaneous indication when the degree of mercury vapor concentration in the air exceeds that which is considered harmless to human beings. This electronic instrument can literally "see" the mercury vapor, which is both odorless and invisible.

P.

Alloys for Die Casting. (*Die Casting*, May 1944.) Magnesium alloys have two outstanding advantages: they have the lowest weight of all die casting alloys and they are the easiest to machine. Both of these properties are important, and where they are of controlling importance the magnesium alloys are the logical choice. The third advantage, namely, the fact that the magnesium alloys do not attack the pot, dies or machine is of considerable significance in terms of die life.

Other advantages, such as castability in both thin and thick sections and to close dimensional limits, are shared with the other commonly used alloys. Obviously, cost per casting will determine to some extent the rate of growth in the use of magnesium alloy die castings; two influential cost factors are the relative cost of the metal itself and the somewhat specialized casting equipment required. The experiences of the last few years lead to the anticipation of marked developments in cost reduction along both these lines.

Magnesium alloys cast at about the same temperature as the aluminum alloys and can often be cast in the same dies. Mechanical properties are also about the same. The strength-weight ratio is higher for the magnesium alloys, since they weigh about two-thirds as much as the aluminum alloys. They are also easier to machine (much easier when compared with the aluminum-silicon alloys). Impact strength is comparatively low, being 1 to 2 ft. lb. Charpy for the A.S.T.M. No. 13 alloy and 1 ft. lb. for the No. 12 alloys.

P.

Gas Turbine Locomotive. (*The Engineer*, Vol. CLXXVII, No. 4607.) Although actual construction of a gas turbine locomotive for trial on American railways has been prevented by war conditions and priority restrictions, research work and design have continued. According to a recent report on this experimental development, the design is for a locomotive of 6000 H.P., weighing 215 tons, and carried on two six-wheeled bogies, with all axles driven by power. A rotary type of prime mover is essential, producing a constant uniform power torque, and as it can be operated at a much higher speed in revolutions per minute, it can be built to develop more power per pound of weight than a reciprocating engine. A steam turbine is not practicable, since it would require too much space and weight for the high-pressure boiler and exhaust steam condenser. The gas turbine eliminates these two items and will be more rugged than a compound steam turbine. It will also use a lowgrade fuel oil of much less cost than the refined distillate used for oil engine locomotives. There will be a direct mechanical power transmission, for while electric transmission has desirable features, its weight is about 25 per cent greater, its first cost and maintenance cost are higher, and its efficiency is less. The drive will be through a combined hydraulic torque converter and hydraulic coupling sets for forward and reverse motion, with dynamic braking through the reverse hydraulic converter. Gears are to be of the hypoid type, and the shafts will have rolling-ball universal joints of a special design. The starting tractive force will be 90,000 lb. No water will be required on the locomotive, except for heating passenger cars. Experimental work includes the use of pulverized coal in connection with the gas turbine, and the development of special alloy steel for the shafts and gears. For marine work it is expected that the gas turbine may compete with other prime movers in point of fuel consumption, weight, space, and part-load performance. Gas turbines are being built for the United States Government, but none is yet in operation.

P.

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